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WHY PNEUMOPERITONEUM?[1]

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FOR the past thirteen years, I have made pneumoperitoneal diagnosis a part of my gynecologic armamentarium and have come to feel that it is one of the most valuable diagnostic procedures we possess. In cases of difficult or obscure diagnosis and in gynecologic differential diagnosis, the pelvic pneumogram has frequently been the means of establishing the true status. Visiting physicians and students are usually startled at the clarity with which the pelvic organs are revealed on the roentgen film and they express amazement that hospitals in general and medical schools in particular do not utilize and teach this method of diagnosis. All who have seen the results of pneumoperitoneum appreciate its value, but they harbor an unwarranted apprehension of harmful effects from the procedure.

Roentgen diagnosis is a relatively recent acquisition in both obstetrics and gynecology. In obstetrics, technical difficulties and the fear of fetal injury had to be overcome before general acceptance of x-ray examination was accomplished (1, 2). The obstetrician now welcomes this diagnostic aid in solving many clincial problems. On the other hand, the gynecologist does not feel the need for roentgenographic corroboration because, as a rule, he is satisfied with a diagnosis achieved by means of a history and a bimanual examination. Even to-day, when pneumoroentgenography has been utilized for over twenty years and uterosalpingography for more than ten years, there are many physicians practising gynecology who are skeptical of the need for these methods. Furthermore, there still appears to be a doubt as to their value and their exists an unfounded fear of danger in their application. The favorable results obtained in cases of sterility following the use of gas or iodized oil for testing tubal patency have tended to overcome to a great extent the doubts concerning uterotubography in this condition. There still exists, however, some fear of injury to healthy fallopian tubes or pelvic peritoneum by the iodized oils employed as contrast media, although evidence is lacking to substantiate this misapprehension. I have examined many histologic sections of normal fallopian tubes removed after lipiodol instillation and have not found evidence of inflammatory change (foreign body giant cells) resulting from iodized oil. The few instances of complications resulting from long retention of lipiodol which have been reported in the literature occurred in cases of chronic tubal inflammation in which the oil lodged in closed cavities. Many gynecologists who admit the merits of roentgen diagnosis in this field nevertheless feel that the method employed makes demands upon their time which they are unwilling to allow.

[1] Presented before the Radiological Society of North America at the Twenty-second Annual Meeting, at Cincinnati, Nov. 30–Dec. 4, 1936.

They are willing however, to subject their patients to exploratory laparotomy which might be unnecessary. There is no denying the fact that time and patience are required of both gynecologist and roentgenologist for lipiodol instillation, induction of the pneumoperitoneum, roentgenography, and particularly for the interpretation of the films. That I consider it time well spent is attested to by the fact that I am still enthusiastic over the methods after an experience of thirteen years, during which I have used them in about 800 patients. During this time, I have indeed been fortunate in the continued co-operation, assistance, and encouragement of my colleague, Dr. R. A. Arens, Director of the Roentgenological Department of Michael Reese Hospital.

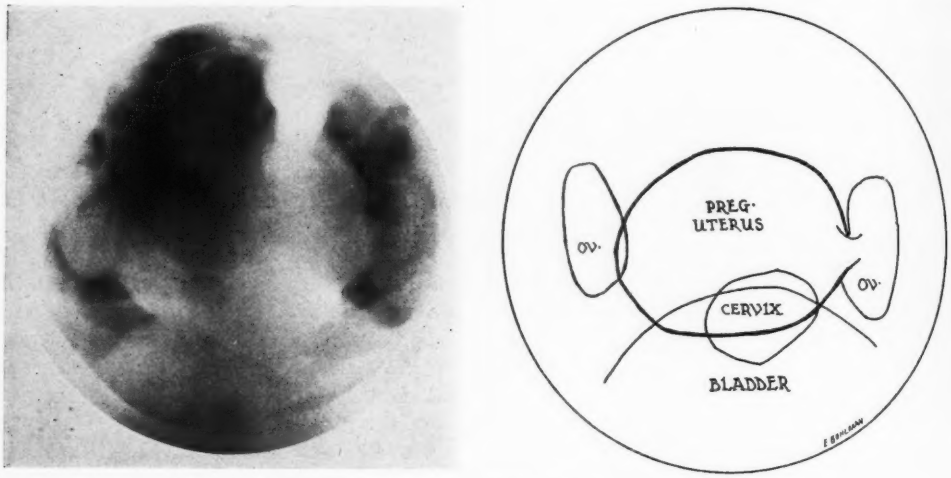
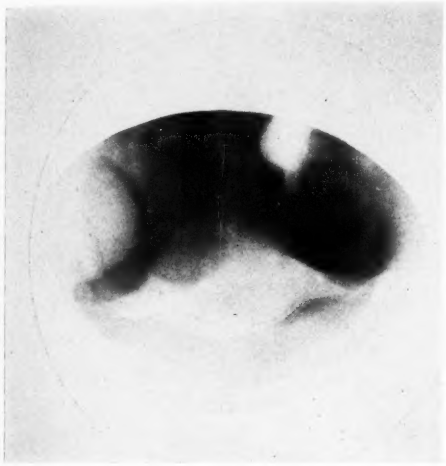


Fig. 1. Transabdominal pneumoperitoneum. Pregnancy, 10 weeks.

DIAGNOSTIC VALUE

Like other laboratory methods, the roentgenogram is employed to complement the data obtained by history and physical examination and thereby support, or at times, refute a previous diagnosis. It is not used in lieu of other diagnostic measures, nor have I employed it as a matter of routine. As previously stated (3), the usual history, bimanual and specular examination suffices to arrive at a diagnosis in the majority of gynecologic conditions. But there are many cases in which the diagnosis is obscure in which the *unusual methods* must be employed. For instance, when the question of pregnancy is involved, it is often not sufficient to determine whether pregnancy is present, but also to determine whether the implantation is intra- or extra-uterine. The biologic test (Friedman) may be employed and, after 48 hours, a reasonably reliable report may be obtained as to whether pregnancy exists, but this does not indicate the location of the nidation. Moreover, in the early weeks, this test may prove negative and if the embryo is dead, as in missed abortion or tubal mole, the result may be misleading. By palpation, one may find a uterus somewhat enlarged and a unilateral tenderness so acute as to lead to a suspicion of tubal pregnancy. Cul-de-sac puncture, blood counts, sedimentation tests, and other diagnostic procedures may prove to be of value, but comparatively, it is my opinion that no test is so valuable as *transabdominal pneumoperitoneum*. In making a differential diagnosis in such cases in which pregnancy is a consideration, I have successfully employed pneumoroentgenography and thereby established the true diagnosis. The following examples

abstracted from my records describe (1) intra-uterine pregnancy, (2) corpus luteum cyst, and (3) unruptured tubal pregnancy in cases in which, prior to the roentgen examination, the diagnosis was in doubt or



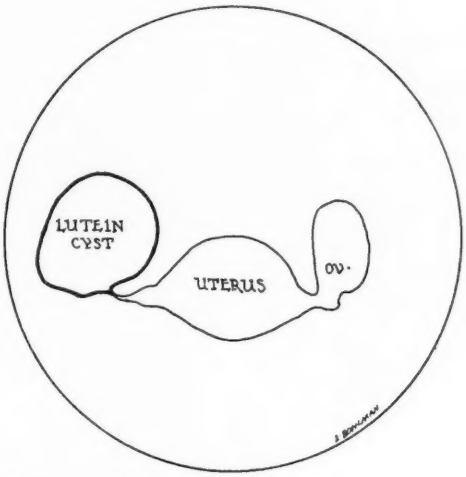


Fig. 2. Transabdominal pneumoperitoneum. Lutein cyst of ovary.

dispute. The film in each instance was the deciding factor in arriving at the correct diagnosis.

Case 1. Mrs. G. F., gr. vii, para iv; three induced abortions (1932, 1934, and Feb. 8, 1936). Menses began at 12 years of age and were of the regular 28-day interval and of four days' duration until the past year, when menses were 23 to 33 days. Last normal period on Jan. 2, 1936, preceded by spotting for five days. Visited a physician on Feb. 8, 1936, for purpose of re-establishing periods. After the treatment, bled for one day. Patient was examined at a prominent university clinic where, on first examination, the chief of the clinic diagnosed *uterine fibroids*, but advised that repeated examination be made. A few days later she was told by the same physician that she had a *tubal* pregnancy. She appeared at my offices on March 4, 1936, complaining of backache, slight pain in the right lower quadrant, and painful right breast. The last regular period had been January 2. Examination revealed an irregularly enlarged uterus about the size of a 10–12 weeks' gestation, with a firm, globular right horn. No adnexal mass was palpable. The isthmus uterii and cervix were soft, and the cervix appeared bluish to inspection. The breasts showed pregnancy hypertrophy. My diagnosis was intra-uterine pregnancy with the probability of a small fibroid in the right horn. The Friedman test was positive. The patient was justly confused by three different diagnoses. She could not reconcile the diagnosis of intra-uterine pregnancy and the abortion which she believed she had obtained in February. However, no tissue had been observed to have been passed, and the slight amount of bleeding hardly warranted the asumption that the abortion had been accomplished.

In order to present additional and more positive evidence of the true pelvic condition, a transabdominal pneumoperitoneum was induced the following day at Michael Reese Hospital. Films made in the partial knee-chest position revealed the typical picture of an intra-uterine pregnancy of about 10 weeks' duration (Fig. 1). No adnexal mass or fibroid was to be seen. (Both conditions could have been readily visualized, if present.) The patient was advised to report back for prenatal care. She subsequently visited a professional

abortionist and the intra-uterine pregnancy was removed. She returned for examination three months later, when a normal genital status was found.

Case 2. Mrs. V. L., age 23, married 14 months; para O. Menses began at 15, every 30 days; 5–6 days' duration; moderate; slight dysmenorrhea first and second day. Last period had occurred on Feb. 6, 1929. When first seen, on March 25, 1929, patient complained that for two weeks she had suffered severe pain and profuse bleeding. At that time she was two weeks overdue and, when seen by the family doctor, was thought to have been pregnant. She was free from pain after this until one week before consulation, when abdominal pains recurred and were present when the patient presented herself for examination.

Bimanual examination revealed an apparently normal-sized uterus, soft, erect. The cervix was soft and the external os was closed. The right adnexæ were negative. There was a very soft and acutely tender swelling in the left adnexæ. Diagnosis rested between tubal pregnancy and corpus luteum cyst.

Transabdominal pneumoperitoneum was performed, the pelvic pneumogram revealing an unmistakably cystic ovary to the left of a normal uterus and right adnexæ (Fig. 2).

The patient was treated expectantly. Menstruation occurred on April 2 and check-up examination on April 9 revealed entirely negative pelvic findings, the cystic condition having entirely disappeared from the ovary. That corpus luteum cysts of the ovary may spontaneously disappear is well known to gynecologists. Not infrequently, women with similar conditions are operated upon, and corpus luteum cysts are found instead of the expected ectopic pregnancy.

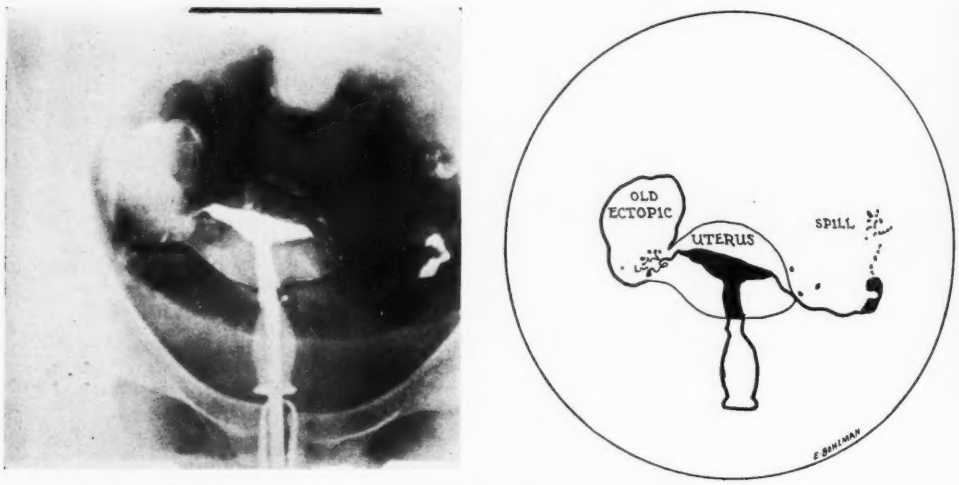


Fig. 3. Transabdominal pneumoperitoneum combined with lipiodol instillation. Old ectopic pregnancy.

Case 3. Mrs. E. W., seen in January, 1931, gave a history of spontaneous abortion at home two months before and bleeding that had continued irregularly since then, accompanied by right pelvic pain. Upon examination, a tender right-sided egg-sized swelling was found. The uterus and left adnexæ were negative. She was informed that the mass was probably a tubal pregnancy and was advised to go into the hospital for operation. Because of economic stress, the patient did not return immediately, but presented herself six months later complaining of continued right-sided pain and irregular bleeding. She was scheduled for pneumoperitoneum

at the hospital, and an associate was delegated to the task. By misunderstanding what was desired, he instilled lipiodol for determining tubal patency and reported that the right tube failed to admit the iodized oil. The procedure was then repeated by the author; a transabdominal pneumoperitoneum was induced combined with lipiodol instillation. The films revealed the pelvis status (Fig. 3). The uterine cavity and the left tube were normal and the tube was patent. The uterus was normal in size and the right tube was enlarged to almost uterine size, oval in shape. It is clearly outlined by the pneumoperitoneum. The lipiodol entered the tubal isthmus and then dispersed into fine channels. I believe this dispersion of the iodized oil in the tube to be characteristic of certain tubal pregnancies in which blood clots fill the tube. The diagnosis from the films readily confirmed the previous one of tubal pregnancy. Operation was performed and a right tubal mole was removed. Recovery was uneventful.

A year later, the patient presented herself because of a two months' amenorrhea, nausea, and vomiting. She was found to be pregnant and was subsequently delivered normally at term.

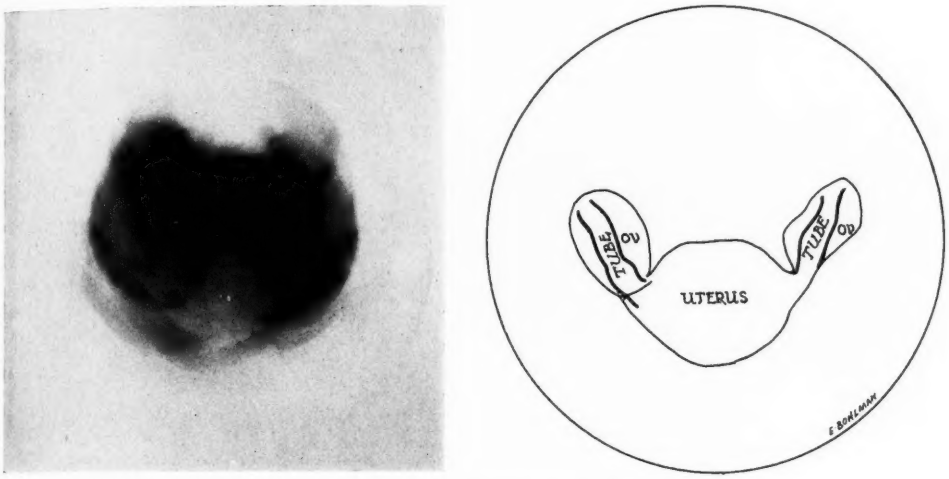


Fig. 4. Transabdominal pneumoperitoneum. Normal status.

Difference in opinion is frequently encountered in cases such as those, with small fibroids associated with pelvic conditions, namely, chronic adnexitis or endometriomata. Patients are confused by conflicting opinions given, and usually welcome, as does also the doctor, some convincing evidence such as may be offered by a pneumograph. In my private practice and in the service at Michael Reese Hospital, it is chiefly in such cases in which differing opinions are offered that I employ diagnostic pneumoperitoneum, as I have learned that in this manner a correct diagnosis can be made without recourse to the exploratory operation. In some such instances, particularly in women suffering from pelvic pain and obese subjects in whom the bimanual examination does not reveal a definite pathologic condition, the film may show perfectly normal pelvic viscera (Fig. 4) and thus obviate the necessity for any operation. On the other hand, the patient may have been ill advised in an instance in which there was real need for surgery as in the case which follows.

Case 4. Mrs. F. P.; age 44, married 22 years; grav. ii. Menses began at 12; irregular 6–8 weeks' intervals; five days' duration; moderate until 1934, when

periods became more profuse the first day and patient complained of pressure pain on rectum.

Examination in October, 1934, revealed an apparently normal uterus. The cervix was scarred from previous repair and several small cysts were palpated on the cervix. Rectal examination was negative. On Feb. 26, 1935, the patient returned because of rectal pain and pelvic discomfort. The uterus was found at this time to be enlarged, hard, and globular. Adnexal findings were indefinite, but there was more tenderness than previously. Specular examination revealed the same cervical and vaginal findings as previously. Hysterectomy was advised.

The patient decided to seek opinion elsewhere. At a university clinic, she was told by the senior attending physician that there was no need for surgery. She then consulted a colleague who advised pneumoperitoneal diagnosis after he also found definite pelvic pathology on bimanual examination. The films (Fig. 5, by courtesy of Dr. M. L. Leventhal) revealed pathology indeed! The uterus was irregularly enlarged, with an oval mass in the right horn having a dense border suggesting calcification. In addition, a dense left adnexal mass and evidence of adhesions were seen. The films demonstrated clearly that there was sufficient pathology in the pelvis to warrant surgical intervention.

In another group of patients, the gynecologist may fail to find any pathologic conditions to account for the patient's symptoms—he may classify them as functional disturbances. Under such circumstances, we have at times been able to disclose by means of pneumoperitoneum, malformations and developmental or glandular alterations of the pelvic organs which explained the symptoms. In this connection, we recently published a series of cases in which bilateral polycystic ovaries were diagnosed, chiefly by means of pneumoperitoneum, in young women complaining of amenorrhea and sterility (4). The ovarian enlargements were not palpable in some instances but were clearly visualized on the pneumogram. The correct diagnosis by means of roentgenographic methods led to the successful surgical treatment and to the ultimate correction of a supposed *functional* derangement (Fig. 6). After operation, menstruation became regular and fertility was restored in these patients.

In establishing the causative factors in

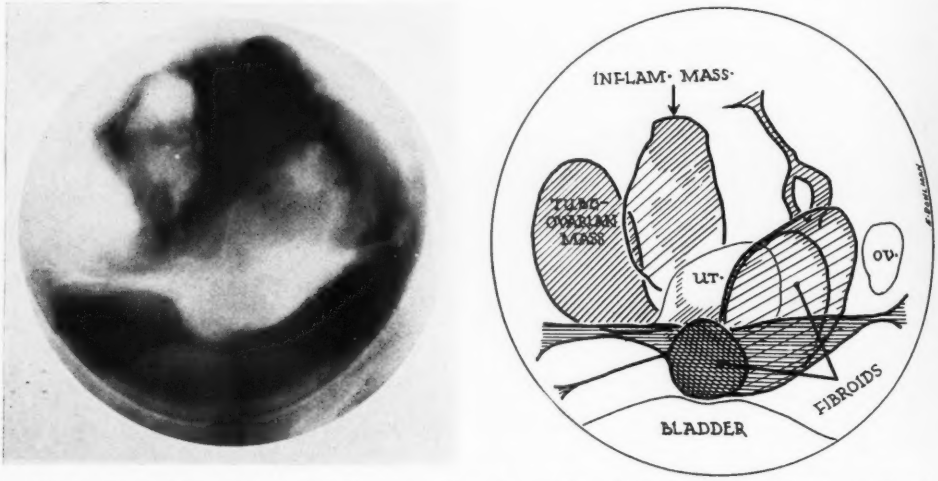


Fig. 5. Transabdominal pneumoperitoneum. Extensive pelvic pathology. Uterine fibroids complicated by adnexal inflammation and adhesions.

cases of sterility, it is often desirable not only to reveal patent tubes, either by gas or by iodized oil, but also to show whether there is any pathologic alteration in the uterus, in the ovaries, and whether there are pelvic adhesions or other pelvic conditions. I have thus frequently found pathologic conditions in addition to that discovered by palpation by employing pneumoperitoneum as a routine in my sterility investigations (5).

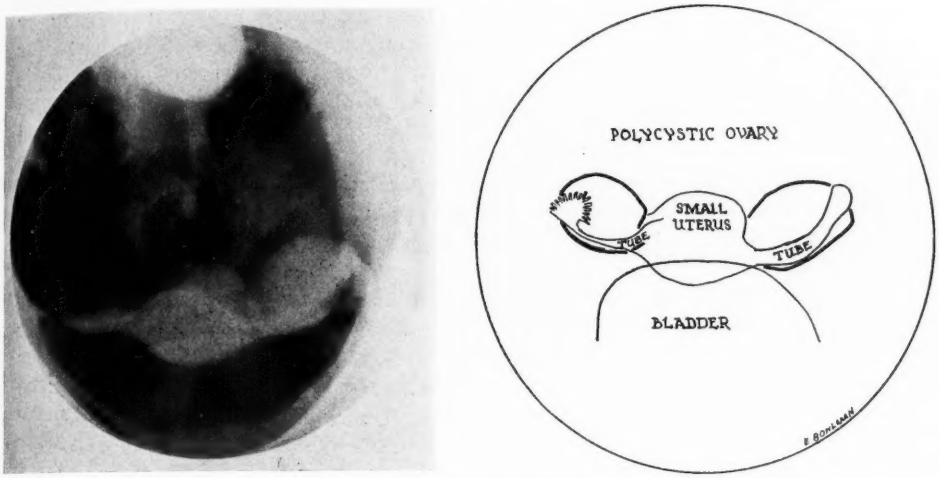


Fig. 6. Transabdominal pneumoperitoneum. Bilateral polycystic ovaries. Single girl, age 20. Never menstruated until after operation.

TEACHING VALUE

Michael Reese ex-internes have frequently written to me after leaving the hospital, expressing their regrets that they have no facilities for pelvic pneumoperitoneum in their present locations, and they have often cited cases wherein it might have been used to good advantage. My students are likewise impressed with the clarity with which the female pelvic organs can be shown on the film, and are puzzled that they do not get instruction and training in their schools in this field. Furthermore, visiting physicians express great surprise when shown the "beautiful films" obtained by pneumoroentgenography, not having realized previously the method's immense diagnostic value. They leave with a resolve to utilize it when they return home.

In addition to their value in clinical diagnosis, the films have proved to be a great asset in illustrating lectures. By means of the pneumogram, we can demonstrate differences in size and shape of the uterus, abnormal doubling, the presence of fibroids—their number and location—often determining thereby whether conservative treatment (myomectomy) may or may not be employed. Ovarian tumors and cysts may be differentiated from each other and from other adnexal conditions. In two instances, I discovered *parovarian cysts* by means of the pneumogram, which diagnosis proved correct at operation. The presence of both ovaries in addition to a globular cyst led to the pre-operative diagnosis. By means of the combined method—iodized oil instillation and pneumoperitoneum—a maximum of information concerning the pelvic organs is obtained. The uterosalpingography reveals the *lumens* and pneumoroentgenography the *contours* of the uterus and adnexæ (6).

DANGERS

The fact that pneumoperitoneum has been used in Michael Reese Hospital for

more than a decade by all members of the gynecologic staff, many times by house physicians, and occasionally by non-staff visiting physicians, without accidents, is adequate answer to the question of danger. In occasional instances, the method has been abandoned short of completion because of discomfort, nervousness, or apprehension on the part of the patient. When no contra-indication exists, the transuterine route is used for inflation, when it becomes a mere prolongation of the patency test. Otherwise, transabdominal puncture is made, the technic for this procedure having been previously published (7). There has never been a bowel or blood vessel injury as a result of puncture in our hands. Gas (CO_2) injected into the adherent omentum has been occasionally observed, appearing at operation as emphysema of the omentum, but no ill effects resulted therefrom.

The pain occasioned by peritoneal puncture and distention is transient and is minimized by preliminary medication with morphine and scopolamine. In some instances, the CO_2 does not absorb as rapidly as one would expect, resulting in shoulder pain and upper abdominal distress which may exist for a few days. However, with pure CO_2, absorption should be complete within a few hours. By hospitalizing the patient for 24 hours, as is my routine, the discomfort is reduced to a negligible minimum. When undue pressure is used in instilling iodized oil into the uterus, injection of the uterine sinuses and pelvic veins occasionally results. This condition has been reported in the literature and usually occurs in cases of tubal obstruction (6). While it is considered to be an error in technic, nevertheless, this complication does not result in harm to the patient.

COMMENT

In my opinion, pelvic roentgenography has proven to be a distinct step forward in gynecologic diagnosis. While uterotubography has been more widely adopted in the study of sterility because of its graphic portrayal of tubal patency or obstruction, pneumoperitoneum is of far greater value in the majority of gynecologic conditions which present difficulties in diagnosis. Furthermore, the combined method offers all of the advantages of both technics. The procedure, while time-consuming, is not difficult or dangerous, providing that intelligence and care be employed. Every x-ray department should be properly equipped with a suitable table to take pelvic roentgenograms after pneumoperitoneum, and gynecologists should be familiar with the technic, so that, in co-operation with the roentgenologist, they can avail themselves of this truly valuable method of diagnosis. Pneumoroentgenography serves as one outstanding method of accurate diagnosis in obscure surgical conditions in the pelvis; contrarily, it may reveal normal pelvic viscera in the presence of symptoms referable to the pelvis, thus obviating the necessity for exploratory operations.

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A COMPARISON OF THE USE OF TRANSUTERINE INSUFFLATION WITH CARBON DIOXIDE AND ROENTGENOGRAMS TAKEN AFTER THE INJECTION OF IODIZED OIL[1]

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TRANSUTERINE insufflation of the fallopian tubes with carbon dioxide has been employed in gynecologic diagnosis since 1920, when Rubin published his technic and observations. Sicard and Forestier, in 1925, reported the injection of a solution of iodine in oil into the uterus and tubes, followed by roentgenograms, in order to visualize these viscera. Stein and others have combined the two procedures with the idea of securing additional information because of greater contrast in the roentgenograms. A considerable literature has accumulated concerning both methods of investigation and concerning combination of the two methods.

Insufflation is a procedure which can be employed safely and satisfactorily in the office. In performing more than 2,000 of these tests no significant sequalæ have occurred. Properly performed, insufflation will give accurate information as to the patency or non-patency of the oviducts. The normal tube will respond to the passage of gas by muscular activity which is transmitted to the kymograph as waves or variations in the pressure necessary to cause the passage of gas through the lumen of the tube. In addition, the relative size of the lumen of the fallopian tube can be estimated by the amount of pressure in millimeters of mercury necessary to force the gas through the tube. Thus, a tube is said to be patent to normal pressure when this pressure does not exceed 100 or at the most 120 mm. of mercury (Fig. 1-*A*), and to be stenosed or relatively obstructed when the gas passes at pressures of from 120 to 200 mm. of mercury. The highest mercury pressure that should be employed is 200 mm. It has been shown that if this pressure does not force the gas through the lumen of the tube, a diagnosis of non-patency may be made (Fig. 1-*B*).

The determination of patency of the tubes to insufflation with carbon dioxide is made by (1) reading the pressure in millimeters of mercury at which the gas passes through the uterus and tubes, making the reading either directly on the manometer scale or on a kymograph connected to the manometer; (2) auscultation over the lower part of the abdomen during performance of the insufflation at which time a definite bubbling sound can be heard as the gas passes through the tubes; (3) the practically invariable elicitation of pain in the shoulder when the patient resumes the upright position after introduction of between 200 and 300 c.c. of gas; this is attributable

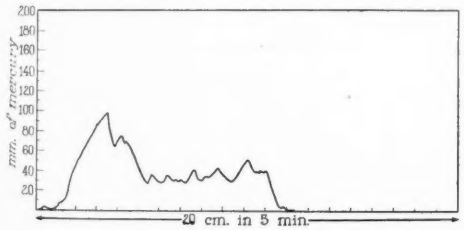

Fig. 1-*A*.

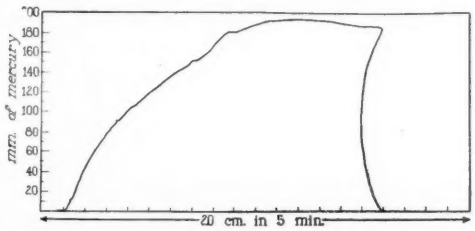

Fig. 1-*B*.

Fig. 1-*A*. Normal patency of the tubes. A kymographic tracing obtained during the transuterine insufflation of normal fallopian tubes that are patent to normal pressure as expressed in millimeters of mercury.
Fig. 1-*B*. Non-patent tubes. A kymographic tracing obtained during the transuterine insufflation of fallopian tubes that are not patent to a pressure of 200 mm. of mercury.

[1] Read before the Radiological Society of North America, at the Twenty-second Annual Meeting at Cincinnati, Nov. 30–Dec. 4, 1936.

to subphrenic pneumoperitoneum; (4) making roentgenograms which may demonstrate this pneumoperitoneum.

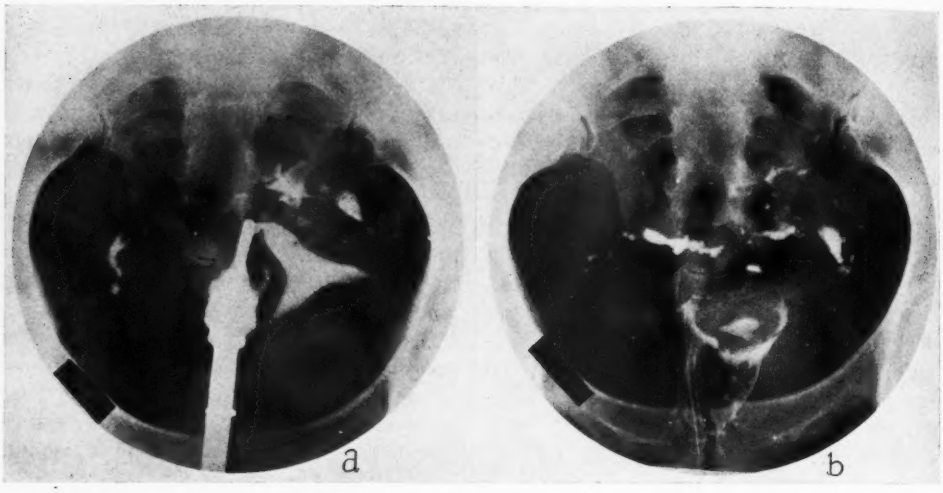

Fig. 2-*A*. Fig. 2-*B*.

Fig. 2-*A*. Normal patency of the tubes. The roentgenogram was taken after the intra-uterine injection of iodized oil which immediately followed the insufflation represented in Figure 1-*A*. Both tubes are filled with the contrast medium.

Fig. 2-*B*. Normal patency of the tubes. This roentgenogram was taken of the same patient represented in Figure 2-*A*, ten minutes after that roentgenogram. The iodized oil has disseminated throughout the pelvic portion of the peritoneal cavity.

The determinations of patency of the tubes in roentgenograms, taken after the injection of iodized oil is based on the demonstration of tubal filling, with spilling of the medium into the peritoneal cavity (Figs. 2-*A* and 2-*B*). This may be observed under the fluoroscope at the time of the injection or in roentgenograms taken at intervals following the injection. When the correct interpretation is in doubt, it is well to make further roentgenographic studies a few hours after the patient has been up and about. At this time, oil which has passed through the tube will be disseminated throughout the pelvic peritoneal cavity. This study is based, primarily, on 600 patients. All received iodized oil and three gave evidence of pelvic inflammation following the injection. These were all instances of chronic salpingitis with tubal occlusion in which oil did not reach the peritoneal cavity.

It has been demonstrated repeatedly that the activity of the muscle surrounding the uterine portion of the fallopian tube may influence the passage of gas or of any medium in the absence of pathologic change. This activity of the muscle may lead to erroneous diagnoses of stenosis or non-patency, regardless of the medium employed. Consequently, it is generally considered best to repeat either or both examinations if the first test fails to reveal the passage of carbon dioxide or of iodized oil. The second examination preferably should be preceded by the hypodermic administration of one-fourth grain (0.016 gm.) of morphine and one-one hundred and fiftieth grain (0.0004 gm.) of atropine. By this means the muscular activity of the uterus is inhibited and no physiologic impediment should exist to the passage of the injection medium.

The technic for the performance of these two tests need not be outlined except to say that a uniform method of procedure was used in the performance of the tests throughout the series.

Following introduction of the method in which a stable solution of iodine in oil is used, at the Clinic we employed transuter-

TABLE I.—COMPARISON OF DIAGNOSES MADE FROM ROENTGENOGRAMS FOLLOWING INJECTION OF IODIZED OIL AND FROM TRANSUTERINE INSUFFLATION OF FALLOPIAN TUBES WITH CARBON DIOXIDE

	Diagnoses Made from Roentgenograms		Diagnoses Made from Transuterine Insufflation	
	Patients	Percentage of 600	Patients	Percentage of 600
Normal tubal patency	324	54	312	52
Chronic salpingitis with tubal patency	81	13.5	126	21
Total, tubal patency	405	67.5	438	73
Chronic salpingitis with occlusion at uterine cornua	113			
Chronic salpingitis with occlusion beyond uterine cornua	82			
Total non-patent tubes	195	32.5	162	27
Total	600		600	

ine insufflation with carbon dioxide and an injection of iodized oil in practically every case in which there was a question as to the permeability of the fallopian tubes. The insufflation was performed first and was followed immediately by injection of the iodized oil. These procedures were carried out on the 600 patients in order to determine the relative accuracy of the two procedures in our hands.

The diagnoses in this group of cases, according to the results of the two tests, are shown in Table I.

It would seem from these figures that the diagnosis of normal tubal patency is made with approximately the same accuracy by both methods of investigation, there being a difference of only 2 per cent in this group. It is interesting to note that nearly half of the women who complained of sterility gave evidence of previous tubal disease.

The diagnosis of chronic salpingitis with tubal patency was made by means of transuterine tubal insufflation in 126 cases (21 per cent) and is based on the need of pressures of between 120 and 200 mm. of mercury to cause the carbon dioxide to pass through the tubes and on a reduction of the number and extent of the fluctuations in pressure that are observed as the gas is passing through the tubes. The kymographic tracing in such a case is represented in Figure 3. The diagnosis of chronic salpingitis with patency of the tubal lumen, made from roentgenograms after injection of iodized oil, has been based on delayed emptying of the tube, evidence of retention of oil in the fimbriated extremity, with subsequent leakage of the oil into the peritoneal cavity, and clear-cut, wire-like tubal shadow with spilling into the peritoneal cavity, marked tortuosity of the tube and evidence of abnormal position of the tube (Figs. 4-*A* and 4-*B*, and 5). I have not been certain in all cases that a diagnosis of chronic salpingitis with patency of the tubal lumen was to be made from the roentgenographic evidence alone, for the roentgenogram may have failed to show sufficient signs to indicate such a diagnosis. A correlation of clinical history, physical examination, and results of insufflation seem necessary for complete diagnosis in many cases. The difference in the number of cases in which this diagnosis was made by the two methods is appreciable (45, 7.5 per cent of 600). This difference seems attributable to the fact that in the group of patients with diseased tubes and patent lumens, insufflation will show the signs of tubal disease more frequently than will roentgenograms. Stenosis of high grade might be found and the patient subsequently might have pneumoperitoneum with pain in the shoulder, but from the roentgenogram it would be impossible to demonstrate oil free in the peritoneal cavity.

The diagnosis of occlusion of the fallopian tubes, made from roentgenograms

taken after injection of iodized oil, is based on failure to demonstrate that the contrast medium has escaped from the tube into the peritoneal cavity. Such a case is represented in Figures 6-*A* and 6-*B* and 7. Results of insufflation indicate occlusion when gas does not pass through the tube at a pressure of 200 mm. of mercury. Figure 1-*B* is a kymographic tracing made during insufflation in a case in which the tubes were not patent. A diagnosis of tubal occlusion was made from the roentgenogram in 195 cases, which is 33 more than the 162 cases in which the same diagnosis was made by insufflation. The explanation of this is the same as the explanation offered for the difference in the results in cases of chronic salpingitis with patency.

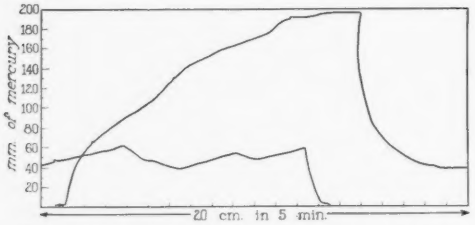

Fig. 3. Chronic salpingitis with patency of the tube. A kymographic tracing which shows a gradual rise in pressure to 200 mm. of mercury, followed by a fall. The tracing lacks the variation in pressure evident in the normal tracing shown in Figure 1-*A*.

That there is a definite effect from muscular resistance is shown in the Figures from 8-*A* to 9-*B*. The first two roentgenograms were taken after an insufflation had failed to produce any evidence of patency or pneumoperitoneum. The last two roentgenograms were made after a preliminary injection of one-fourth grain of morphine and one-one hundred and fiftieth grain of atropine and show that the tubes were normally patent. It is easy to understand the error in diagnosis that can be made when this condition is present. When evidence is obtained at the time of performance of either test to indicate that normal patency does not exist, the examinations always should be repeated after administration of some drug that is capable of relaxing the uterine and tubal muscles. There were 92 cases in which the examinations were thus repeated. In 54 of them the initial diagnosis was that of non-patent tubes and this

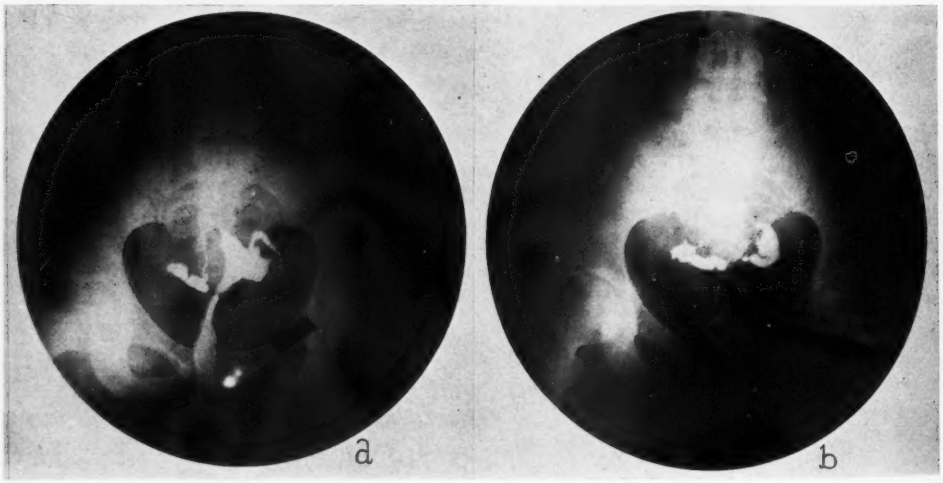

Fig. 4-*A*. Fig. 4-*B*.

Fig. 4-*A*. Chronic salpingitis with patency of the tube. This roentgenogram was taken following the injection of iodized oil which immediately followed the insufflation represented in the kymographic tracing shown in Figure 3. The right tube presents a wire-like shadow that extends down toward the cul-de-sac. There is a collection of oil in the region of the fimbriated end of this tube. On the left side the tube is tortuous, angulated, directed toward the cul-de-sac and presents a collection of oil at the fimbriated end.

Fig. 4-*B*. Chronic salpingitis with patency of the tube. This roentgenogram was taken ten minutes later than that shown in Figure 4-*A*. The collections of oil in the region of the fimbriated ends of the fallopian tubes retain the same appearance as in the first film and no oil can be demonstrated to be free in the peritoneal cavity.

Fig. 5. Chronic salpingitis with patency of the tube. This roentgenogram was taken 24 hours later than that represented in Figure 4-*A*. The shadow in the region of the fimbriated end of the right fallopian tube is virtually the same as in the previous two roentgenograms. On the left, however, the dense mass of oil has been smeared and there is definite evidence of dissemination of oil through the pelvic portion of the peritoneal cavity.

Fig. 7. Non-patent tubes. This roentgenogram was taken 24 hours later than that represented in Figure 6-*A* and shows the retention of the oil in the tubes.

was confirmed after repeated tests. In nine cases a diagnosis of chronic salpingitis with patency was made at the initial examination and was confirmed by repeated test. In 19 cases the initial test indicated non-patent tubes but further examinations, after the administration of morphine and atropine, revealed a normal kymographic tracing and a normal roentgenogram. There were 10 cases in which the initial tests apparently revealed non-patent tubes but in which subsequent ex-

Fig. 6-*A*. Fig. 6-*B*.

Fig. 6-*A*. Non-patent tubes. This roentgenogram was taken immediately following an insufflation that revealed a kymographic tracing similar to that shown in Figure 1-*B*. Both tubes have filled to the fimbriated ends but no oil can be seen to have entered the peritoneal cavity.

Fig. 6-*B*. Non-patent tubes. This roentgenogram was taken ten minutes later than that shown in Figure 6-*A*. The contrast medium is still retained in the lumina of the tubes.

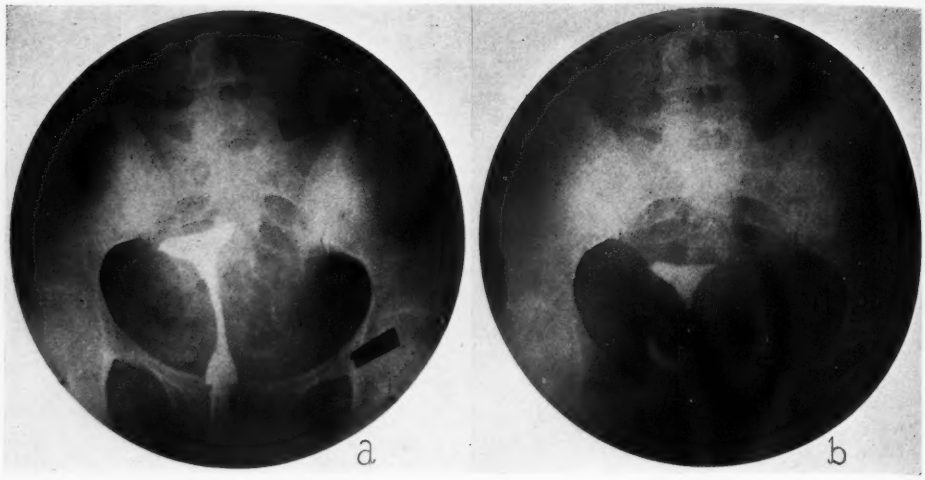

Fig. 8-*A*. Fig. 8-*B*.

Fig. 8-*A*. Muscular resistance to injection of media. This roentgenogram was taken after an insufflation had resulted in a kymographic tracing similar to that shown in Figure 1-*B*, indicating non-patent tubes. The uterus is filled with the medium but no oil has reached the lumen of the tubes or the peritoneal cavity.

Fig. 8-*B*. Muscular resistance to the injection of media. A roentgenogram made 10 minutes later than that represented in Figure 8-*A*. It shows the uterus to be in the process of emptying but no oil is observed in the tubes or peritoneal cavity.

aminations gave results that indicated chronic salpingitis with patency. Thus, there were 29 cases in which acceptance of the results of the first examination would have resulted in error in diagnosis as determined by repeated investigation. Re-

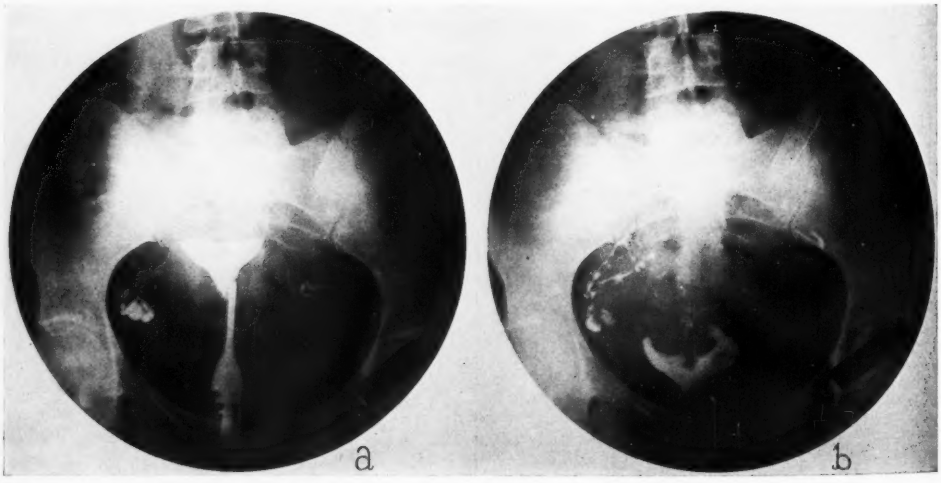

Fig. 9-*A*. Fig. 9-*B*.

Fig. 9-*A*. Muscular resistance to the injection of media. This roentgenogram was made four days later, of the same patient as the one represented in Figures 8-*A* and *B*. One-fourth of morphine and $^1/_{150}$ grain of atropine had been administered hypodermically 45 minutes previous to the examination. The uterus and tubes are filled with the oil.

Fig. 9-*B*. Muscular resistance to the injection of media. In this roentgenogram the tubes are partially empty and oil can be seen to be free in the peritoneal cavity. The patient was the same as the one represented in Figures 8-*A* and *B* and 9-*A*.

TABLE II.—RESULTS OF REPEATED EXAMINATIONS

	Cases
Repeated investigations made	92
Initial diagnosis of non-patent tubes confirmed	54
Initial diagnosis of chronic salpingitis with patency confirmed	9
Initial diagnosis of non-patent tubes changed to one of normal patency	19
Initial diagnosis of non-patent tubes changed to one of chronic salpingitis and patency	10

sults of these repeated examinations are presented in Table II.

The present procedure at the Clinic is first to perform insufflation in all cases in which there is a complaint of sterility, and if normal patency is determined but the patient does not present evidence of pathologic change in the pelvic viscera on the performance of careful pelvic examination, examination with iodized oil is not considered necessary. However, if non-patency is diagnosed, or if the tubes are patent to high pressures, or if palpable adnexal disease is evident, a second examination is performed, using iodized oil. Presuming that a uniform and careful technic is employed there is little to choose between these two methods of diagnosis in the case in which the tubes are normal. When chronic tubal disease with patent tubes exists I believe that transuterine insufflation and injection of iodized oil both should be performed.

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ROENTGENOGRAPHY IN OBSTETRICS[1]

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ROENTGEN could neither have visualized the magnitude of his discovery nor the perfection of technic which was to follow. Its applications have become infinitely numerous and conveniently yield positive information, in obstetrics alone, to say nothing of the dependence of the other branches of medicine upon this specialty.

According to Orley (1), the first radiography of the pelvis was performed by Varnier and Chappius in 1896, on the cadaver, and required an exposure of three hours. In 1897, Professor Budin exhibited a radiograph of a Naegele pelvis; the exposure time was 45 minutes. Our expectations, constantly becoming more demanding, have resulted in the production of sharp films with a minimum time of exposure.

APPLICATION TO CONDITIONS PARTICULARLY AFFECTING THE MOTHER

With the aid of pneumoperitoneum, Peterson (2) has diagnosed pregnancy at six weeks. In this manner, the shadow of the enlarged uterus may be made visible. If it were not for the hazard of abortion, the diagnosis could be made at a much earlier date using intra-uterine opaque media; the embryo produces a filling defect of the uterus. Incidentally, since the point of nidation predetermines the place of development of the placenta, the future site of that organ can be ascertained. Bartholomew, Sale, and Calloway (3) in a systematic study, have obtained positive evidence of the fetal skeleton in one-third of their cases at five months, one-half at six months, and almost constantly, thereafter. A positive roentgenogram is the most confirmatory evidence of pregnancy (Figs. 1 and 2). Because the Aschheim-Zondek test is positive in 98 per cent of cases, and is not attended with any risk, it should supersede x-ray diagnosis in the early weeks. Extra-uterine pregnancy may be diagnosed even after the fourth month, by injecting the uterus with lipiodol. During normal pregnancy the uterine cavity is obliterated at this time. However, one should realize that decision to employ this procedure, in any case, must follow great deliberation, for the outcome may be unfortunate should the embryo be located in the uterus.

Effort to locate the placental site, especially in cases in which the possibility of placenta prævia or ablatio placentæ presents itself, may be enhanced by the flat film in many cases, and by amniography in practically all cases. The flat film shows the presenting part to be displaced over the pelvic brim, because of interference of the bulk of the placenta. Following the injection of strontium iodide, thorotrast, or uroselectan through the abdominal wall into the uterine cavity, amniograms taken in the anteroposterior and lateral positions should outline the placenta as well as the umbilical cord and fetal parts; in male babies the genital organs may be revealed, thus diagnosing the sex. Amniography should not be resorted to unless one is ready to welcome the onset of labor, which is reported as a natural sequence in a fair percentage of cases. The drug itself seems to have no harmful effect and is rapidly eliminated. Titus (4) suggests that with the injection of 20 c.c. of sodium iodide into the bladder, the roentgenograms will usually show a filling defect, or a contrast shadow of the placenta.

[1] Presented by invitation before the Radiological Society of North America at the Twenty-second Annual Meeting at Cincinnati, Nov. 30–Dec. 4, 1936.

Fig. 1.

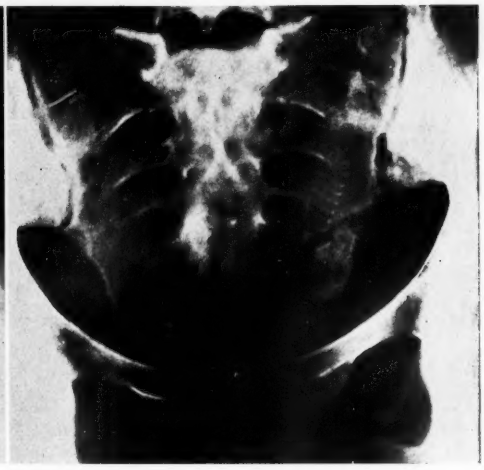

Fig. 2.

Fig. 1. Pregnancy of less than 93 days. Diagnosis made by Dr. Joseph F. Elward. Both lateral margins of the chest and also the spinal column are visible, as indicated by arrows.
Fig. 2. Pregnancy of less than 112 days diagnosed by Dr. Joseph F. Elward.
Other methods of diagnosing early pregnancy are either attended with certain dangers or are subject to error. This method of diagnosis is safe and positive. Films have not been retouched.

Pregnancy produces a laxity of the pelvic joints, permitting greater mobility of the iliac bones on a transverse axis through the sacrum. We now consider a widening of the pubic symphysis as depicted by the x-ray, to be one of the physiologic changes attending late pregnancy. Some observers believe that the widening designates absorption rather than separation of bone. I am inclined to think that the effect is produced by a softening and thickening of the ligaments, probably a change which occurs in the birth canal preparatory to labor.

It is surprising to note that although the importance of the configuration of the bony pelvis in relation to the successful outcome of labor was emphasized as early as 1572 by Arantius (5), it was not until recently that attention was called to the contour of the inlet, with its effect upon engagement of the fetal skull, as well as pelvic architecture and its effect upon the mechanism of labor. The knowledge furnished by roentgenography has enabled the expression of opinion as to what actually occurs during labor, and as to the tenability of the hard and fast text book theories which we were taught. Those who studied medicine prior to a few years ago, are now surprised to learn that the pelvic inlet is not necessarily shaped like a flat heart. *The normal variations* which we recognize in the contour of this plane, I should like to divide into two types: First, those that may be discerned by even a layman; second, the type less easily detected, but of interest to the trained obstetrician. In the first class may be placed any inlet with a marked departure from the normal contour, such as the four parent types described by Caldwell, Moloy, and D'Esopo (6) (Fig. 3). In the anthropoid type (ape), engagement occurs with the longitudinal suture in the anteroposterior diameter, usually as an occipitoposterior. In the platypelloid type (flat), engagement is expected with the longitudinal suture in the transverse diameter of the inlet. In the gynecoid type (female), the longitudinal suture lies in one of the oblique diameters. In the android pelvis (male), engagement would have a tendency to occur in the transverse diameter, but the architecture below the brim is such as to favor the occurrence of the mechanism of

persistent occipitoposterior. In the second class would belong the mixed types of assimilation pelvis (four sacral vertebræ) and such cases as split pelvis and absence

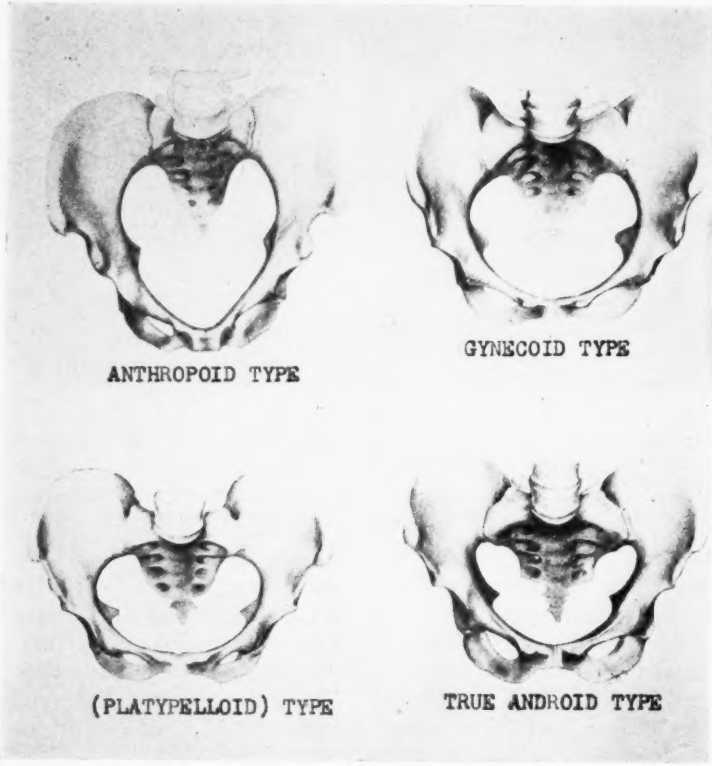

Fig. 3. The four parent types of pelves as described by Caldwell, Moloy, and D'Esopo. Even a layman can detect the difference in the inlet contours. Since adaptation is an important factor in engagement, and resulting mechanism, the shape of the inlet plays an important part.

Most pelves show a blending of types, and differences in contour may be detected only by the trained eye. (Caldwell, Moloy, and D'Esopo in Amer. Jour. of Obst. and Gyn., C. V. Mosby Co., Publishers.)

pelves, by far the most common, which are described by the same authors. They have also described the true pelvis and outlet which are usually associated with the four parent types, information that has definite bearing upon the mechanisms of labor.

Abnormal variations in the contour and architecture of the female pelvis may be conveniently classified into the congenital, acquired, and traumatic. Congenital abnormalities are the Roberts' pelvis (absence of sacral alæ), Naegele pelvis (absence or shortening of one ala), the high assimilation pelvis (six sacral vertebræ), the low of pubic or ischial rami, excellent examples of which have recently been called to my attention at the Johns Hopkins clinic. The last two cases were discovered accidentally during routine pelvimetric study. Pelvic deformities may be acquired from rachitis, poliomyelitis (Fig. 4), tuberculosis, osteomalacia, and hip and joint diseases. Marked asymmetry often follows fracture of the pelvis or poor results from a fractured femur in childhood. The ordinary flat plate does not reveal discrepancies in pelvic symmetry, unless they are unusually marked (Fig. 4). Careful scrutiny of the pelvis, using a technic in which we are

certain that the inlet and film are parallel, or the use of the precision stereoscope, should reveal the true configuration of the inlet. No case of fracture of the pelvis in any female up to the age of the menopause should be discharged without such a study, for there may result certain interference with the function of childbearing. Neglect to do this may cause embarrassment.

Again I wish to stress that the shape of the brim and the architecture of the true pelvis, as well as the pelvic outlet, have a definite influence upon the mechanism of labor. One of the fascinations of such study is that no man can predict what the radiogram will reveal.

From the standpoint of mechanisms, the obstetrician must consider pelvic inclination, or the angulation of the plane of the inlet toward the horizon. Recently Garnett and I (7) have directed attention to the significance of faulty inclination as a cause of dystocia, even in pelves of normal size. Faulty inclination usually exists in patients possessing the dystocia dystrophia type of syndrome; they are short stubby individuals with high vertical symphysis and heavy bony skeleton. We have shown that the roentgen ray in the lateral view affords absolute knowledge of this condition. Furthermore, I (7) have found that pelvic inclination varies in all women and that the average is more favorable than has been generally recognized. Instead of the inlet making an angle of 30 degrees with the horizon in the recumbent posture, it makes an angle of 42 degrees, thus approaching a perpendicular to the longitudinal axis of the fetus and the forces of expulsion, and favoring entrance of the presenting part into the brim (Fig. 5).

No definite relationship exists between the true and external conjugate diameters, for the thickness of bones varies in different individuals. It is possible for two women to have equal external conjugates, while their true conjugates may vary as much as three or four cm. in length. The roentgenogram, of course, may reveal such facts.

Matthews (28) has suggested other uses

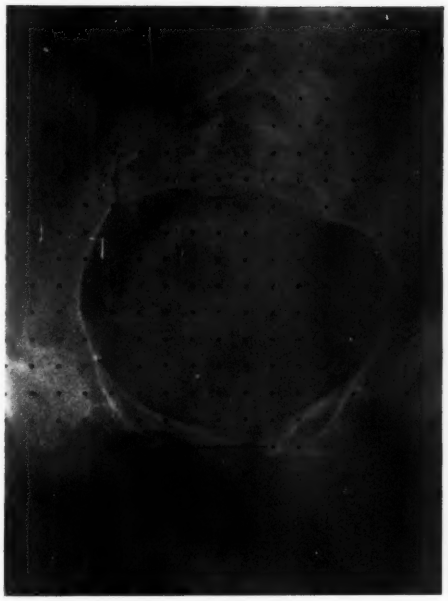

Fig. 4. The plane of the superior strait in a patient that had had poliomyelitis in childhood. She is unable to walk and although this pelvis is unusually small, she has had two babies normally. Film was parallel to inlet, by author's technic. In an ordinary flat film, the contour of this inlet was overlooked. Fig. 15-*A* is a lateral view of this patient. T. C. checks in both films. Length of true conjugate as calculated with author's inclinometer was 9.4 cm.

of the x-ray, such as diagnosis of bony tumors, healing after pubiotomy, differential diagnosis of fibroid tumors or myomas with or without pregnancy, ovarian cysts and dermoids; also in pseudocyesis. Reinberger and Russell (8) claim to have seen the contraction ring in several cases of dystocia; I have not had such an experience. They advise the study of dystocia by anteroposterior and lateral films, and they believe that they can early diagnose gas bacillus infection, when the film discloses the presence of gas in the uterus.

Since focal infections seem to influence the incidence of toxemias of pregnancy, I might mention the customary use of the x-ray in locating such foci.

Roentgenographic studies of the urinary tract are of value in observing the physiologic changes incident to pregnancy, as well as the abnormalities, such as kinking of the

ureters and dilatation of the ureters and pelves. Hayes (9) has found that such conditions are commonly observed in the toxemias of pregnancy, and he believes that relief from the resulting urinary back pressure results in rapid recovery.

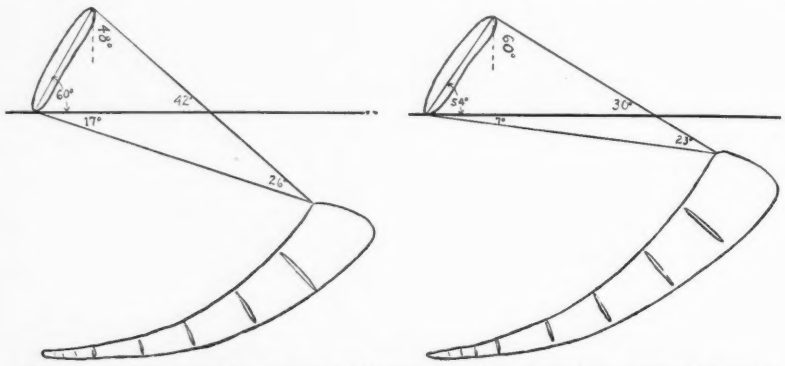

Fig. 5. In a study made in a series of living women, I have found the average inclination of the pelvis to be 42 degrees in the recumbent posture. Formerly it was presumed to be 30 degrees. As the plane of the inlet tends to become perpendicular to the spinal column, engagement of the presenting part is facilitated. (Garnett and Jacobs in Amer. Jour. Obst. and Gyn., C. V. Mosby Co., Publishers.)

THE DETERMINATION OF FACTORS CONCERNING THE FETUS BEFORE BIRTH

During late pregnancy the obstetrician is concerned with the presentation of the fetus or the relationship of its long axis to that of the mother. In all cases in which doubt exists, radiography immediately furnishes such information.

Variety, which is defined as the relationship of an arbitrarily chosen point on the presenting part to the right and left and anterior and posterior portions of the mother's pelvis, is determined by obtaining anteroposterior and lateral views, then associating the two films. The flat stereoscopic view should give similar information.

Absolute knowledge of multiple pregnancy and position of the babies affords the obstetrician the requisite sense of security. Both an anteroposterior and a lateral view are usually advisable.

Occasionally, monstrosities are detected accidentally during the course of roentgenologic examination. At other times the roentgenogram is requested because of abnormal clinical findings. Hydrocephalus is not uncommonly diagnosed, because the large skull is revealed, and occasionally irregularities in the contour of the skull signify the enlarged fontanels. If other anomalies may be discerned, then more especially, should an amniogram be taken.

Although death *in utero* does not warrant operative intervention unless certain clinical symptoms and signs are present, one prefers to be in possession of such knowledge as early as possible. In my own experience, definite roentgenological evidence of fetal death is noted as a late change. Schnitker, Hodges, and Whitacre (10) have expressed similar conclusions. In their study, overlapping of fetal skull bones (Spalding's sign) was noted in only 25 per cent of dead babies; they warn that this phenomenon might have been present in a live baby if the patient had been in labor and that in hydramnios overlapping will probably not occur. Angulation of the spine, although found in 50 per cent of their dead babies, was also found in many live babies; in these cases they wisely resort to mathematical probabilities and determine the age of the fetus as compared to the duration of pregnancy. Collapse of the thoracic cage as described by Matthews (28) does not occur with any regular frequency. Decalcification has been described as evidence of fetal death, but neither is this sign well warranted. A

lithopedion, of course, may be easily visualized.

In the last few years, the determination of the age of the fetus *in utero* has been approached from several viewpoints. This statement also applies to the weight of the fetus *in utero*.

Some authors judge the age from the appearance of epiphyseal ossification centers, the most important being the center for lower epiphysis of the femur which usually makes its appearance during the ninth month of pregnancy, and that for the upper epiphysis of the tibia which makes its appearance just prior to or just after birth. Shaw (11) states that this is not a reliable index, since in some cases the epiphysis of the femur is not present at birth, while the epiphysis of the tibia may be present at 37 weeks.

Thoms (5) states that the head usually lies with the occipitofrontal diameter in the transverse of the inlet, and therefore the x-ray in the supine position gives this measurement. From this he computes the biparietal diameter, the weight and length of the fetus. In a breech presentation it would be advisable to take the exposure in prone position in order to bring the fetal head closer to the film and also to prevent mobility.

Hodges (10) determines the occipitofrontal diameter and uses the graph of combined equations of Scammon and Calkins (12) to estimate the age in calendar months; or it may be estimated in weeks (Fig. 6). In some instances there is a margin as great as eight weeks between the minimum and maximum age for a particular diameter, although the margin decreases somewhat when the lesser age groups are under consideration. I feel that one who is experienced can gauge by abdominal palpation the age of the fetus with as great a degree of accuracy. I am informed that Hodges makes similar determinations using the average circumference of the skull. The weight and viability may also be estimated from charts.

Occasionally one attempts to determine fetal maturity from the length of long bones as obtained by the x-ray. In this respect I agree with Shaw (11), who feels that the procedure is rather futile because the distance and the plane of the long bones are unknown. The stereoscopic view, however, would enable more accurate estimation than a single exposure.

THE APPLICATION OF THE ROENTGEN RAY TO THE FETUS AFTER BIRTH

The time of appearance of the centers of ossification have been determined. None of the ossification centers are visible before the seventh week of intra-uterine life. The centers for the clavicles appear first at seven weeks. The one for the os calcis appears during the fifth month; the astragalus appears at the seventh month, and the cuboid at the ninth month. A complete radiographic table of the centers of ossification is given by Dorland and Hubeny (13), reference to which often can be relied upon to establish the age of the fetus.

Rachitic bone changes are a swelling of the outline of the cartilage; the epiphyseal center has a moth-eaten appearance, and the zone of temporary calcification is a thin line.

In syphilis there is an osteochondritis, with absence of a sharply marked zone of calcification between the cartilage and the growing bone. These changes, according to Williams (14), are most readily recognized at the lower end of the femur and lower ends of the tibia and radius.

Proof of extra-uterine life may be obtained from exposures of the fetal chest, which show whether the lungs have been expanded. Atelectasis may be diagnosed also.

Fractures, dislocations, and other skeletal defects may be recognized.

Visceral anomalies, especially of the intestinal tract, may be observed after suitable introduction of opaque media.

PELVIMETRY AND CEPHALOMETRY

As far back as 1896, Varnier and Pinard (1), working at the Baudeloque Clinic in Paris, estimated the various inlet diameters of pelves by comparing the obtained

roentgenograms with those of dried pelves placed in the same position.

Albert (1), in 1897, was the first to understand the importance of having the inlet

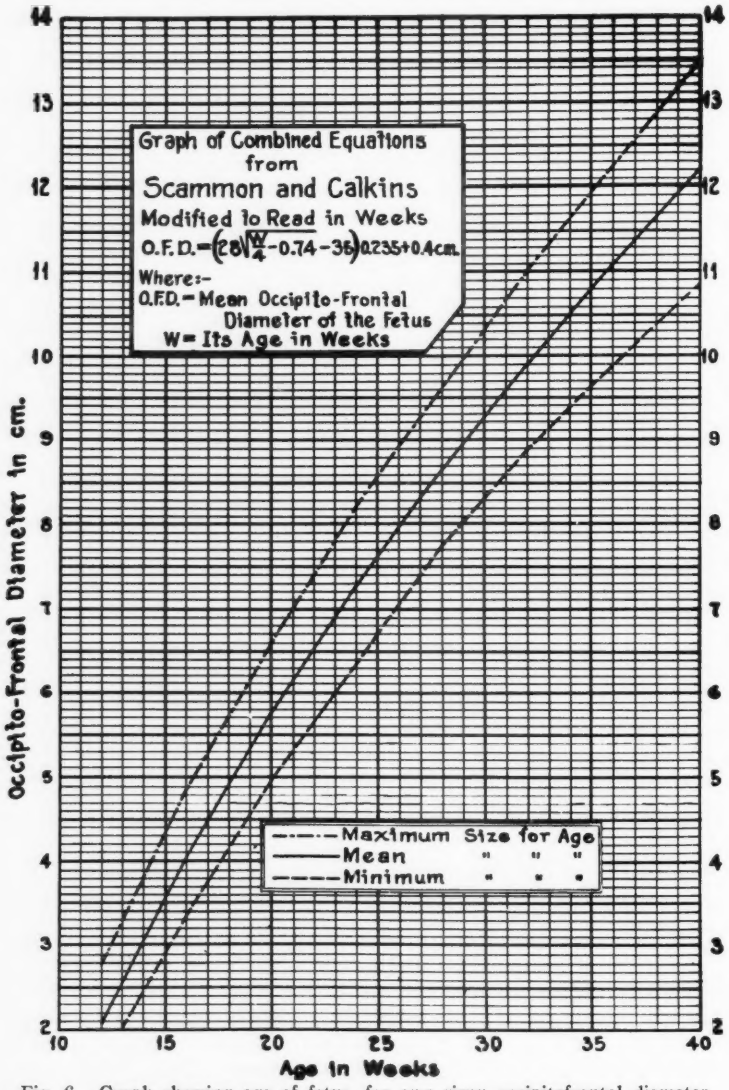

Fig. 6. Graph showing age of fetus, for any given occipitofrontal diameter. For any length, note the wide margin of error. (Scammon and Calkins.)

In 1900, Varnier (1), in an effort to overcome distortion, placed the tube five meters away from the patient. It is difficult to imagine that he had any success, for in spite of evolutionary improvements as late as 1929, similar efforts made by Elward and myself at distances of only six feet were unsuccessful.

parallel to the film, and several of the standard technics, including my own, are based upon that principle.

Time will not permit a discussion of all the contributions made to roentgenographic pelvimetry. In this country pioneer work has been done by Thoms, and it was through his continued effort that others

became interested in a subject that previously appeared to be very unattractive.

It shall be my purpose to describe very briefly some of the technics which are being popularized to-day and to comment upon the relative merits of each. Then I should like to proceed with a more detailed description of the procedures evolving from the use of the obstetric inclinometer (15) which I had devised and published in 1928, a technic which has served me very satisfactorily.

Thoms (16) places the patient on the usual x-ray table, in a semi-sitting posture, in an effort to cause the inlet to be parallel with the film. The tube is centered over the approximate middle of the inlet, this point being about two inches posterior to the upper border of the symphysis; exposure is then made. The distance of the tube to the film is noted. Then the distance of inlet to film is determined by locating certain external landmarks which are presumed to lie in the plane of the inlet, and measuring their height above the film.

The patient is then removed from the table and a thin lead plate, with perforations 1 cm. apart throughout its surface, is placed in the position formerly occupied by the inlet. A flash exposure is made on the original film. The perforations appear as black dots on the developed film, and the distance between the individual dots is enlarged in the same proportion as the image of the inlet. Thus the anteroposterior and transverse diameters of the inlet are measured by counting the dots.

Thoms (5) presumes that the fetal head usually lies with the occipitofrontal diameter in the transverse, and I believe that in most instances this is true. Therefore, with the patient in the supine position, and using a technic similar to that just described, he obtains this measurement, which he claims is accurate. From this diameter he computes the biparietal diameter, and the weight and length (crown to heel measurement) of the fetus.

Comment.—Since the true and external conjugates do not lie in the same plane, it is impossible to tell when the inlet is parallel to the film in any of the "position technics." Experimenting with the bony pelvis, I (25) have shown that discrepancy of only five degrees between the inlet and film produces an error of 0.5 cm.; an error as great as 1 cm. could easily be encountered. In spite of my observations, I feel that this method has definite value.

The technic as to cephalometry is very simple, and were we sure of the absolute transverse position of the head in all cases, and were we able to measure the exact elevation of the mid-plane above the table, an accurate reading could be obtained. Cephalometry, by my own technic, is based upon similar assumptions; and so I have felt somewhat justified in stressing its importance. In some cases, no doubt, the determinations are of value, but there is too much room for error, and it would be unwise policy for one's judgment to be guided in all cases by such procedure.

Walton's (17) "position method" is very similar to that of Thoms, except that for measuring distortion he uses a correction chart instead of the lead grid with cm. perforations. Such a "false centimeter scale" could be constructed for any fixed tube-film distance.

The flat surface of the head (occipitofrontal) is measured as by Thoms. With the patient in the supine position, and the film supported vertically on one side of the patient while the tube is directed from the opposite side toward the midpoint of the head, the biparietal diameter is determined.

Comment.—We are not sure that the inlet is parallel to the film. The false centimeter chart is practical, time-saving, and ingenious. This method also has practical utility. My views regarding the technic of cephalometry are identical with those already expressed. I might add, incidentally, that I have tried taking lateral roentgenograms for pelvic measurements, with the patient in supine position, in the manner that Walton measures the biparietal diameter, but had little success.

Jarcho's (18) technic for both pelvimetry and cephalometry differs but very little

from those already described. In order to position the inlet, the patient is placed in almost a sitting position, with legs hanging downward over the edge of the table. He uses the perforated lead grid for measuring the distortion.

Comment.—Advantages and disadvantages are similiar to those previously mentioned. In centering the tube over the inlet, due to the sitting position, the rays must penetrate a rather long diameter of the fetus and uterus; this is not a desirable feature.

Ball (19) has approached the problem of cephalo-pelvic determinations from a unique point of view. He takes an anteroposterior and a lateral picture of the pelvis. With the pelvicephalometer which he has devised, he attempts to ascertain the volume of the fetal skull, and the volume capacity of the most common smaller pelvic diameters, namely, the true conjugate, and the distance between the ischial spines. His instrument, like a map tracer, records the circumference of the skull on both films, which are right-angle views; the mean of the two is the average circumference of a sphere. He next determines the height of the mid-plane of the skull above the film, which is easily noted on the lateral view. The indicator on the face of the instrument allows for correction due to variable distance of head over film and denotes the volume of the skull in milliliters.

The instrument then measures the length of the true conjugate diameter from a lateral view and the volume capacity of a sphere of that diameter, corrected for its distance above the film as observed on the anteroposterior view (from symphysis to trochanter), is recorded on the dial.

Similarly, the volume capacity of the bi-ischial spine diameter, as noted in the flat plate, and corrected for its distances over the film as observed on the lateral view, is recorded by the indicator on the instrument. Ball makes some allowance for the thickness of the scalp and moldability.

Comment.—There are several factors which may be variable. One is not certain that the cephalic perimeters are those of perpendicular planes; this permits of error in computation of skull volume. Images are larger than the objects which are x-rayed; therefore it is difficult to note accurately the distance of spines to film on the lateral view . . . . an important correction factor in computing the volume capacity of the bi-ischial spine diameter. Likewise, there is a certain compressibility of the tissues over the great trochanter which would affect computation of volumetric capacity of the true conjugate. Regardless of whether linear or volumetric comparisons are made between the head and pelvis, it is always possible for the long diameter of a skull to engage or encounter the short diameter of a pelvic plane, resulting in dystocia. Were the head soft instead of bony, a shift in volume would occur, enabling its passage. It must be admitted, however, that the head, being more or less oval in shape, is more apt to accommodate itself to pelvic diameters, and that in most cases, volumetric comparisons if made at term, should prove of great value. I am not in favor of making a cephalo-pelvic study early in pregnancy, and then with the aid of a graph determining the rate of increase in volume of the skull, because graphs are merely averages, and in borderline cases the rule of averages may increase complications by interference with judgment.

Johnson's (20) method of stereoroentgenometry is based upon the principle of localization of foreign bodies. Orley (1) states that as early as 1901 Contremoulins used the Mackenzie-Davidson cross-thread method of localization of foreign bodies for pelvic measurements. He took two exposures on the same plate, each from a different point, and then reconstructed the course of the x-rays with threads, thus identifying the important points in space. Haenish, in 1912, built a special apparatus for this purpose; he took two exposures on two separate films and then transferred the

points from which measurements had to be made to a drawing. The drawing was then placed in the position occupied by the plate, and the two x-ray beams were reconstructed.

In 1929, Johnson (21) described his technic wherby two stereoscopic views are made with a given target-film distance and a fixed vertical shift of tube. One at a time, the films are placed in a view box and important identical landmarks localized on both films. His stereoroentgenometer consists of a view box directed upward (incorporated in a table top), with an upright rod of target to film height extending from the back of the table, and supporting a horizontal rod from which are suspended two strings at points which correspond to the target positions when the roentgenograms were taken. The two films, properly superimposed, are placed upon the glass surface of the view box, so that their center is directly beneath the midpoint between the origin of the two threads. To measure the true conjugate diameter hold the lower ends of the threads over the two points designating the sacral promontory, while an indicator is fixed in space at the intersection of the threads. Thus is established the location of the sacral promontory in space. Similarly, place an indicator at the intersection of the strings when their lower ends are applied to points designating the middle of the upper border of the symphysis. The exact position of the diameter then is shown by the two indicators in space, and the distance between them is the actual length of the true conjugate diameter. In like manner, Johnson states that he can measure any diameter of the pelvis, or any diameter of the fetal skull.

Comment.—The technicalities here involved are accuracy in construction of apparatus and in procedure. There must be assurance that films are properly superimposed, that the midpoint between the tube shift is exactly over the center of films, and that all distances are definitely fixed. This impresses me as being an accurate technic of more practical value, and I shall make a comprehensive study of its application.

Clifford's (22) technic, except for slight individual modifications, is similar to that of Johnson.

Comment.—He seems to be primarily interested in mensuration of the fetal skull in order to determine by reference to a compilation of similar data (in form of a graph), the maturity of the fetus or its viability; which information is of value in the conduct of certain cases complicated by toxemia, heart disease, vaginal bleeding, diabetes, pyelitis, etc. Because of his inability to visualize the promontory of the sacrum, his remarks are discrediting as to roentgenographic pelvimetry, and he regards the test of cephalo-pelvic disproportion as the old reliable test of labor.... a fact of some value.

Concerning his remarks on pelvimetry, I disagree, for it shall presently be shown that the important pelvic diameters can be measured by a simple and accurate technic. And at this point, I desire to state that in my opinion cephalic mensuration does not compare in practical importance with pelvic mensuration. The pelvis is fixed in both position and size in all its planes and dimensions. The head, on the contrary, is subject to changes in position as well as size, due to such factors as movability of the fetus as a whole *in utero*, rotation of the skull on its vertical axis, or flexion and extension through its transverse axis, moldability, the shape and inclination of the inlet, interference from soft parts, etc.

There is less variation in contour and size of fetal skulls at term than there is in the configuration and size of the pelvis. So, although we desire and regard information as to the size of the head as being helpful in order to understand the mechanism and prognosis of labor, the information furnished by accurate pelvimetry is vastly more important. From the viewpoint of the pediatrician, much interesting research work may be done through cephalometry as regards the development of the fetus. From the practical point of view of the obstetrician, I must call attention to the wide margin of error, in estimating ma-

turity, in some cases being as great as several weeks, between estimated minimum and maximum age; and there may be a range of as much as 1,000 grams or more in weight. In some cases such information may be of great value, but it should not be emphasized to the point of exclusion of such a simple and practical procedure of reliable value, as mere palpation of the fundus by the hand of the experienced obstetrician. After all, the law of averages does not apply to individual cases.

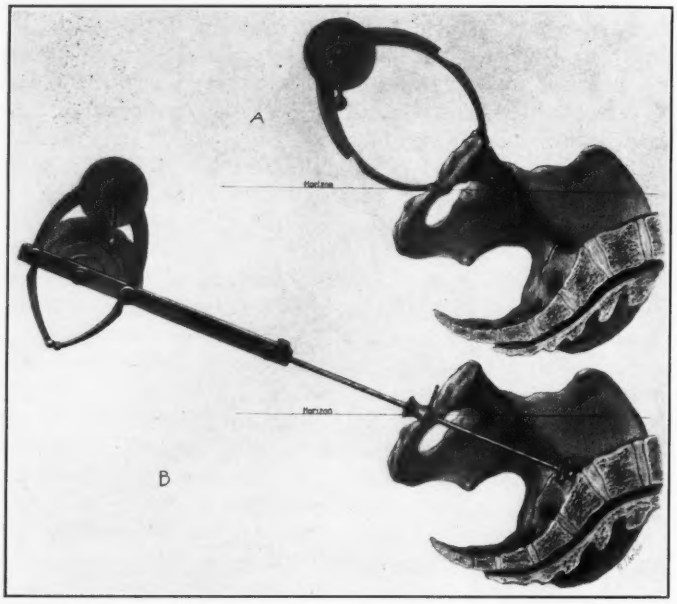

Fig. 7. In upper drawing, caliper of Bay Jacobs' Inclinometer records height and inclination (angle with horizon) of symphysis. In lower drawing, the length and inclination of diagonal conjugate are noted. (Jacobs in Amer. Jour. Obst. and Gyn., C. V. Mosby Co., Publishers.)

Hodges' (10, 23) work does not differ materially from that of Johnson, although he is very precise in his technic. Stereoscopic views are taken, and using a map tracer, the occipitofrontal diameter of the skull is measured on each film and the average noted. The films are then accurately superimposed and placed in the view box, and the distance between the two identical points at each end of the diameter is noted. This is called the parallax shift. Hodges has developed a formula for the correction of triangular distortion, from which the correction factor may be derived where the parallax has been accurately measured, and the tube-film and tube-shift distances are known. The average occipitofrontal diameter, when multiplied by the average correction factor, yields the corrected diameter in the anteroposterior view. The age in weeks of the fetus may be determined by applying the calculated fetal head diameter to the graph of combined equations from Scammon and Calkins (12).

Hodges seems to be principally interested in cephalometry.

To measure the length of the true conjugate, the anteroposterior view is practically worthless because of the inability to accurately locate the endpoints of that pelvic diameter. Therefore, the lateral view is highly desirable for a determination of this pelvic diameter, and technic

similar to that used in cephalometry would be carried out on a stereoscopic pair of films. The length of the diameter on each film is measured and the average obtained. This average is multiplied by a correction factor derived from an average of the parallax shifts of the endpoints of that line, *i.e.*, the sacral promontory and the upper margin of the posterior surface of the symphysis pubis. It becomes necessary to average these two parallax shifts whenever the endpoints are not equidistant from the film.

Comment.—This author is doing admirable work, but here again I believe that the importance of cephalometry is being overemphasized in relation to pelvimetry. Also in determining the age of fetus the margin between minimum and maximum age, for certain measurements, may be as great as eight weeks.

Hodges' published work differs from Johnson's in that the diameter is obtained by graphic means, instead of with the aid of the stereoroentgenometer.

Caldwell, Moloy, and D'Esopo (6) in their roentgenographic work stress particularly such factors as pelvic contours, disproportion, the mechanisms of labor and prognosis. From their work has evolved the excellent classification of pelves which is being rapidly recognized as having definite value.

I believe that at present most of their work is being done with the patient in supine position, using a lumbosacral pad in order to overcome the disadvantage of markedly oblique inlet views.

Comment.—These men have made a definite contribution to obstetrics, and the observations which they present will teach men to realize that the views previously stated in text books were very narrow, tending to limit the mental development and conception of medical students, as applied to obstetrics.

Author's Method.—My own procedure of pelvimetric roentgenography as applied to borderline pelves, may be divided into three stages.

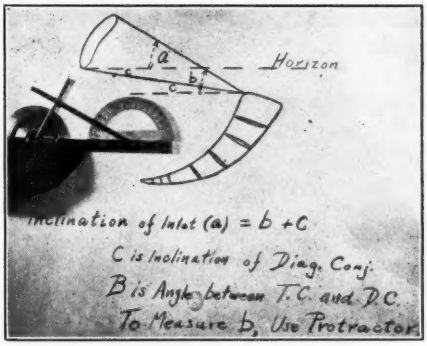

Fig. 8. The diagram depicted is a reproduction of the calculator held in the hand. The scales of the calculator denote the three sides of the *obstetric triangle*, which is that formed by the symphysis, the diagonal conjugate and the true conjugate. Thus with the use of the calculator one may determine the inclination of the inlet. (Jacobs in Southern Medical Journal.)

(1) *Observations made with the author's obstetric inclinometer* (15, 24).
(2) *The anteroposterior roentgenogram* (25).
(3) *The lateral pelvic roentgenogram* (26, 27).

(1) *The observations made with obstetric inclinometer.*—The obstetric inclinometer consists of a vaginal measuring rod, a calculator, and a caliper, modified to record angles as well as distances.

When the caliper is applied to the upper and lower borders of the symphysis, the height and inclination of the symphysis are noted (Fig. 7). With the instrument assembled, and the end of the rod carried to the sacral promontory by the examining fingers, while the rod is in contact with the lower border of the symphysis, the length of the diagonal conjugate and its inclination are noted (Fig. 7).

The angle of inclination of the symphysis, plus that of the diagonal conjugate, equals the angle between the symphysis and the diagonal conjugate (Fig. 7). Thus knowing the two sides and included angle of a triangle, the third side, or true conjugate diameter, is readily computed with the calculator, which enables reconstruc-

tion of the triangle designated by the author as the *obstetric triangle* (15) (Fig. 8).

To proceed with the next operation, namely, the anteroposterior roentgenogram,

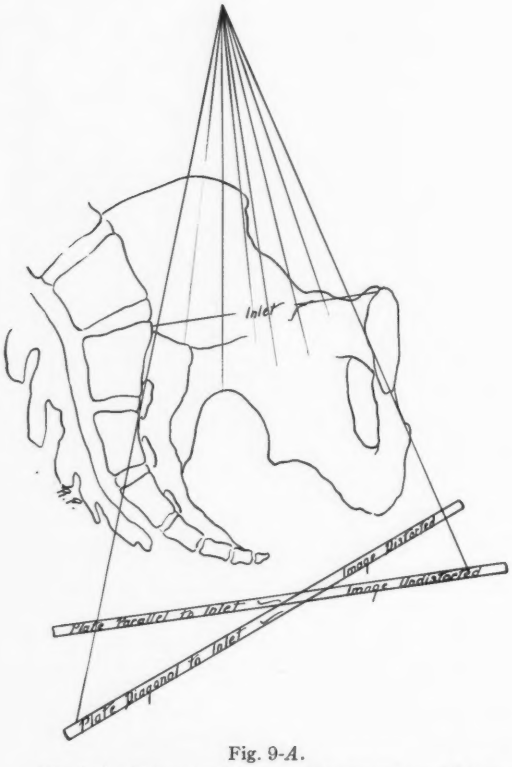

Fig. 9-*A*.

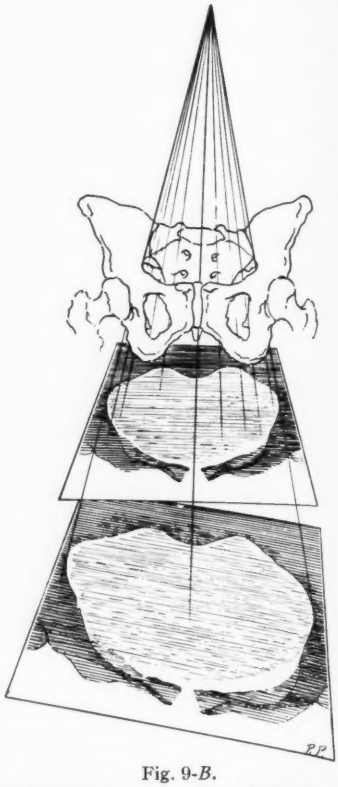

Fig. 9-*B*.

Fig. 9-*A*. When the inlet and film are not parallel, measurements are inaccurate. Thus in *A*, the image of the posterior portion of the inlet is enlarged as compared to the anterior portion when plate is diagonal to inlet; posterior portion is enlarged; anterior portion is somewhat foreshortened. Where the plate is parallel, all distortion is uniform and measurable.

Fig. 9-*B*. Shows disturbance and asymmetry in image of contour of inlet, due to unparallelism (lower film). The upper film is parallel, and image is symmetrical and uniformly enlarged. Symmetrical enlargement is measurable.

I consider this triangle as being unusually important because it is concerned with the most important pelvic dimension (true conjugate), and the inclinations of the pelvic inlet and symphysis, factors which have a direct bearing upon the facility of engagement of the presenting part of the fetus. The dimensions of the sides, as well as the size of the angles of this triangle, vary in all women. Notation is made of the length of the true conjugate diameter, for this is used as a check upon the results obtained in anteroposterior (25) and lateral pelvic roentgenography (26).

the inclination of the inlet must be determined. At present I am using the principle of the "position method," making certain that the inlet and film are parallel, in order to avoid unequal distortion (Figs. 9-*A* and 9-*B*).

The inclination of the inlet is obtained in one of the two following ways:

(*a*) With the aid of a protractor, from any point on a horizontal line, lay off the height and angulation of the symphysis; the same is done for the diagonal conjugate. The top of the line representing the symphysis is joined by a straight line with the

end of the diagonal conjugate; at the point where this line (true conjugate) crosses the horizon, the protractor may determine the *angle of inclination of the inlet* (15) (Fig. 10-*A*).

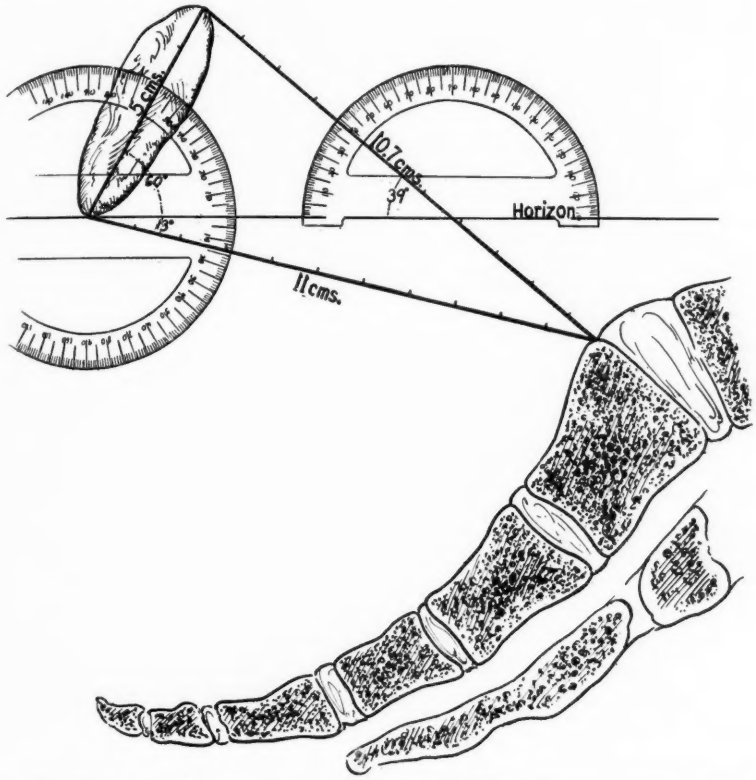

Fig. 10-*A*. Simple pelvigram. *Inclination of inlet* is 39 degrees. True conjugate measures 10.7 cm. The calculator yields the same measurement.

(*b*) Reconstruct the interior of the pelvis with the calculator (the obstetric triangle). With an ordinary protractor measure the angle between the scales that designate the diagonal conjugate and true conjugate diameters. Adding this angle to the inclination of the diagonal conjugate, gives the *inclination of the pelvis or inlet* (25) (Fig. 8).

(2) *The Anteroposterior Roentgenogram.*—The patient is placed upon a wooden table in supine position, the buttocks at the end of the table, with legs extended and separated widely, being supported by special leg rests or narrow tables (27). Now instead of positioning the patient, the film is positioned, for the cassette is placed under and close to the buttocks at the same angle as the inlet. Fastened to the cassette with adhesive strips, is the Lysholm grid. The tube is positioned over the approximate center of the inlet and perpendicular to it and the film (Fig. 11). Any inaccuracy in this set-up produces unequal distortion, resulting in error (Figs. 9-*A* and 9-*B*). Exposure is made, and before removing patient from table, the target-to-inlet and inlet-to-film distances are measured.

A perforated lead grid, similar to the one devised by Thoms, except that the grid rides straight up and down on two calibrated rods, is interposed between the exposed film and target at a point corresponding to the station of the inlet (Fig. 12). Flash exposure is made.

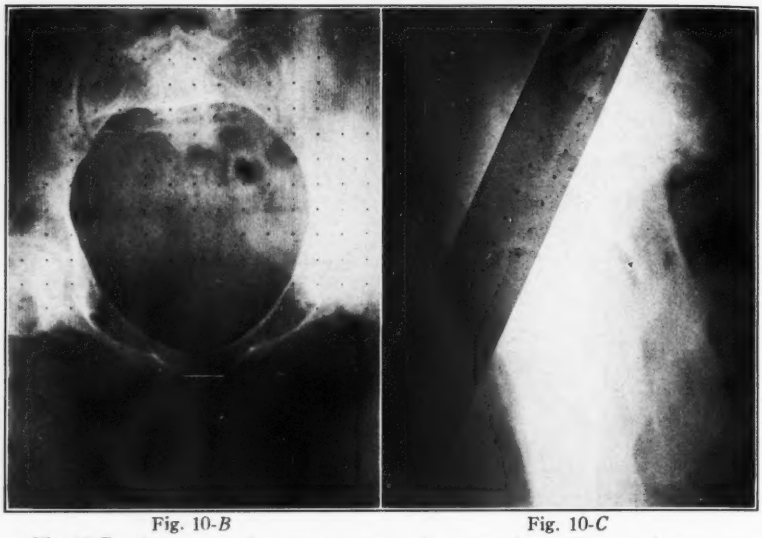

Fig. 10-*B* Fig. 10-*C*

Fig. 10-*B*. Anteroposterior roentgenogram of same patient. True conjugate measures 10.7 cm.

Fig. 10-*C*. Lateral pelvic roentgenogram of same patient. True conjugate measures 10.7 cm. (Jacobs in Amer. Jour. Obst. and Gyn., C. V. Mosby Co., Publishers.)

The resulting film is accurate and clear for several reasons. The advantage of the Lysholm grid is evident from Figures 13-*A* and 13-*B*, showing a film taken with and one without, its use.

Also, with the patient in the recumbent posture, she is more comfortable and the rays do not have to pierce almost the entire length of the uterus and fetus, as occurs when she is positioned and the film is fixed. The contour of the inlet as well as the sacral promontory shows up well in these films; this landmark is not visible in films taken by some of the other technics.

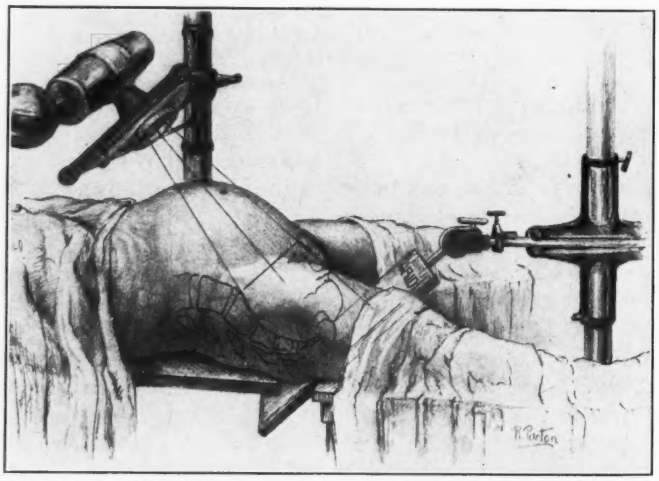

Fig. 11. Position for anteroposterior roentgenogram. Buttocks at end of table and legs supported as shown. Inclination of inlet, determined as described in Figure 8 or Figure 10-*A*, is known. Lysholm grid is fastened to cassette, which is made parallel to inlet. Tube is positioned so center ray will be perpendicular to middle of inlet. Exposure made. (Jacobs in Amer. Jour. Obst. and Gyn., C. V. Mosby Co., Publishers.)

Should the fetal head lie with its longitudinal suture in the transverse of the inlet, as it often does, one may determine the occipito-frontal diameter. By counting the dots on the film, the true conjugate and transverse diameters of the inlet are measured. Should one desire to measure the oblique diameters of the inlet, he may do so with a ruler or straight edge, and then place the ruler along a line of dots and count the centimeters in that distance; in a previous paper, I have explained why this is necessary (26). The encroachment of the ischial spines upon the true pelvis may also be observed. Permit me to emphasize, as I have repeatedly done, that the middle of the upper border of the symphysis on such a film is situated as shown in Figure 10-*B* or 13-*A*.

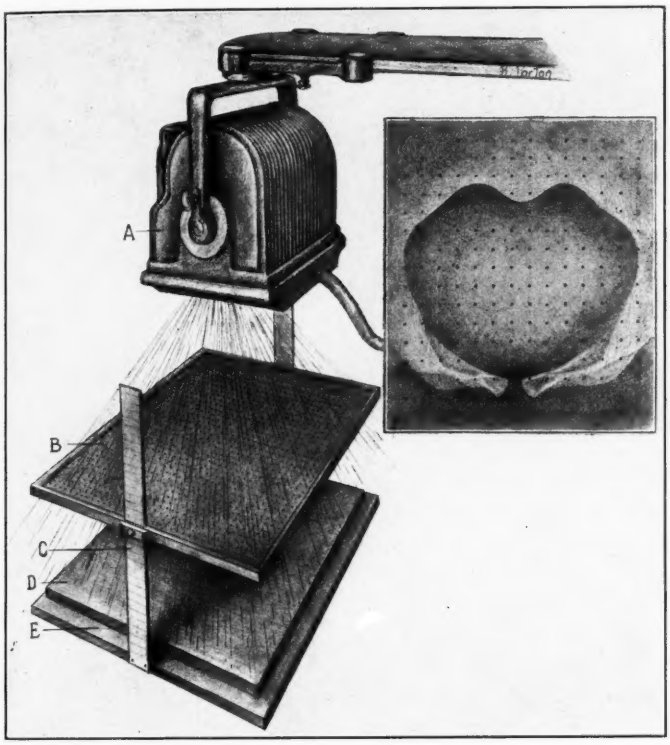

Fig. 12. *A* points to target. *B* is lead plate with perforations 1 cm. apart throughout its surface, as first used by Thoms. *C* is calibrated rod. *D* is cassette containing exposed film. *E* is base of apparatus. *A* to *B* is target-to-inlet distance. *B* to *D* is inlet-to-film distance. Insert *F*, shows the doubly exposed film, after it is developed. (Jacobs in Amer. Jour. Obst. and Gyn., C. V. Mosby Co., Publishers.)

(3) *The Lateral Pelvic Roentgenogram.*—The lateral pelvic roentgenogram is probably the simplest, most accurate, least uncomfortable, and most inexpensive procedure. After attempting many positions, I have finally decided upon the following technic:

The patient stands with her side securely fastened to a vertical Bucky diaphragm, so that corresponding landmarks of both sides of the pelvis coincide (Fig. 14). The center ray is directed perpendicular to the middle of the true conjugate diameter, which externally corresponds to a point about one inch posterior to the anterior inferior iliac spine (this point is best located in recumbent posture). Exposure is made, and then the target-to-inlet (genital crease), and

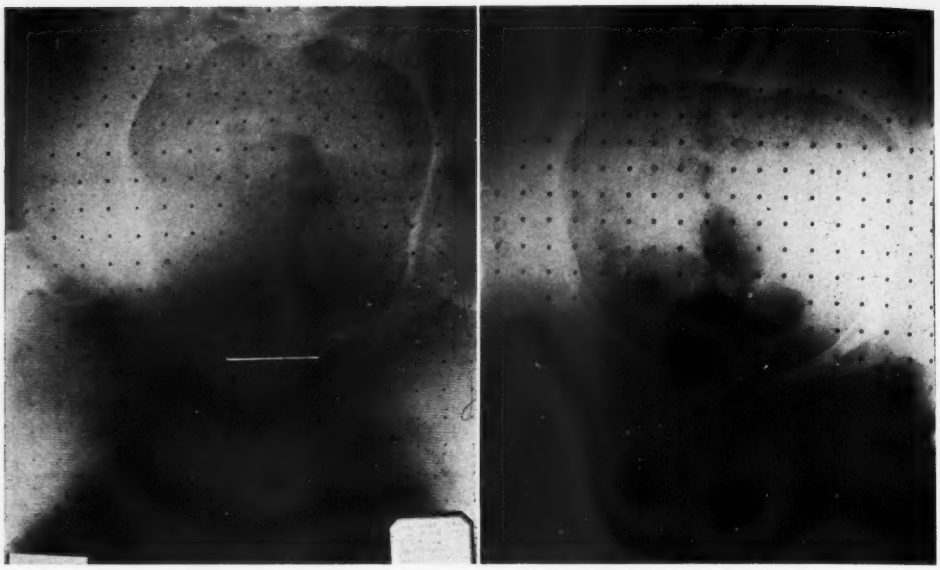

Fig. 13-*A*. Anteroposterior view taken with Lysholm grid.

Fig. 13-*B*. Anteroposterior view taken without Lysholm grid.

inlet-to-film distances are measured before the patient is removed. The perforated lead grid is then interposed between target and film, in the relationship formerly held by the inlet. Flash exposure (second exposure) is made, transferring dots to film (Fig. 10-*C*).

I have previously explained (26) why two films must be used if one desires to have a line of dots extended from upper border of symphysis to promontory of sacrum (Fig. 10-*C*, Fig. 15). In cases in which one film is used, note the distance with a straight edge or a pair of dividers, between these two points, and then place on a line of dots and count the centimeters in the length of the true conjugate. Similarly, the size of the sacro-sciatic notch and the thickness of the sacrum may be measured.

Since many advantages of the lateral roentgenogram were elaborated upon in a former publication (26), I shall merely make brief reference to them at this time. By this procedure:

The bulk of fetus, uterus, and aminotic fluid are avoided.

The landmarks of the true conjugate are evident.

Pelvic inclination is noted as well as ability to engage.

I have shown by x-ray that changes in posture cause alteration of pelvic inclination; also variation in size of the sacro-sciatic notch, with corresponding effect upon posterior pelvic capacity.

Rachitic changes in sacrum and existence of false promontory may be noted.

Engagement and progress of descent during labor can be visualized.

Should the long axis of the head lie in the transverse diameter of the inlet, the biparietal diameter can be rather carefully measured, for its mid-plane is practically in the line of the genital crease.

Disproportion may be noted (Fig. 16).

CONCLUSIONS

1. The amount of roentgenographic exposure to which the mother and fetus are subjected for diagnostic procedures has been found to be free from danger. Excessive doses, such as used for treatment, may in early pregnancy cause death of the

fetus and abortion; in late pregnancy they may interfere with the growth of the fetus hold a foremost place in the management of all borderline cases.

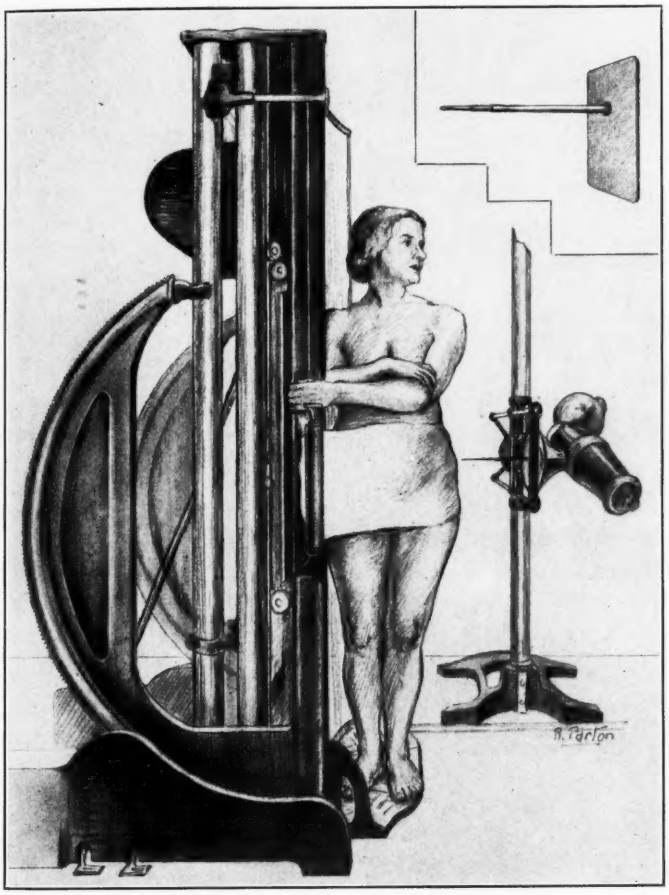

Fig. 14. Set-up for taking lateral roentgenogram. In this position the fetal head is not apt to move. The apparatus shown in insert is a telescopic indicator which I had devised for noting direction of center ray; after tube is positioned, this apparatus is removed. (Jacobs in Amer. Jour. Obst. and Gyn., C. V. Mosby Co., Publishers.)

after birth; in the mother the ovarian follicles may be seriously affected.

2. The numerous applications of roentgenology to obstetrics should necessitate roentgenographic facilities in all hospitals where obstetrics is done; many unfortunate results may be avoided.

3. I am not advocating my technic to the exclusion of all others. I do, however, feel that such a simple and valuable procedure as lateral roentgenography should

4. Though I may have appeared too critical in commenting upon other technics, I wish to stress the fact that the authors referred to are masters, and I am among the first to respectfully value the highly scientific quality of their work.

5. Regardless of the technic used or advocated, we are educating the obstetrician to its indispensibility.

6. For simplicity, an ordinary flat plate will yield an image from which one can de-

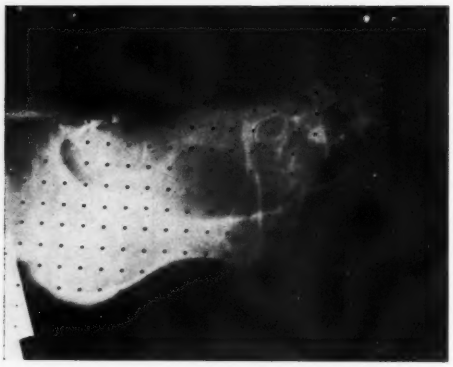

Fig. 15-*A*

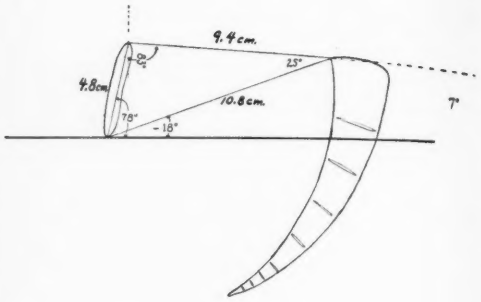

Fig. 15-*B*

Fig. 15-*A*. Lateral roentgenogram of same patient depicted in Figure 4. Note that the length of the true conjugate checks within 2 mm. with the T. C. as in Figure 4. Note also that inclination of inlet is very faulty. The head has to make a right angle turn to enter this pelvis. Note the extreme forward rotation of the femur and the distorted pelvic architecture. In this technic, a separate film was used for the dots, and then this was properly superimposed on the first film.

Fig. 15-*B*. Length of true conjugate as calculated with author's obstetric inclinometer and by a pelvigram was 9.4 cm. Short labor; normal delivery; weight of infant 6 lbs. 7 oz. (Thighs flexed on abdomen during labor, to permit engagement of head.)

termine the transverse of the inlet, by using either the grid, or Roberts' simple formula. An ordinary flat plate, however, has very little other value and frequently is responsible for the mismanagement of an obstetrical case. The other important diameter of the inlet, namely, the true conjugate, is readily measured on an ordinary lateral view using either the perforated lead grid or Roberts' equation. Thus no reasonable excuse may be offered for avoiding the advantages of x-ray pelvimetry, at least in indicated cases.

Fig. 16. Lateral view showing disproportion. True conjugate measures 11.4 cm. Biparietal diameter measures 12.8 cm. After delivery biparietal measured 13 cm.

7. At times the roentgenogram yields information which is unexpected and surprising.

8. In my own procedure, the measurement of the true conjugate diameter must check three ways (two cases depicted); namely, (1) Its length as calculated with my obstetric inclinometer or a pelvigram Case 1 (Fig. 10-*A*), Case 2 (Fig. 15-*B*). (2) Its length as measured on an anteroposterior roentgenogram Case 1 (Fig. 10-*B*) Case 2 (Fig. 4). (3) Its length as determined on a lateral pelvic roentgenogram Case 1 (Fig. 10-*C*) Case 2 (Fig. 15-*A*).

9. I feel that too much attention is being centered upon the determination of fetal maturity, although I do not overlook the importance of such knowledge in a small margin of cases. Unfortunately, reference must be made to a highly potential factor, such as the law of averages.

10. In stating opinion regarding any x-ray procedure, I have tried to express the practical views of an obstetrician.

11. The relationship between obstetrics and roentgenology seems to be one-sided; the obstetrician is dependent upon the roentgenologist.

12. It should be definitely understood, however, that in spite of many valuable interpretations made available through roentgenography, its application should not supersede clinical judgment, as derived from the use of the mind, the eye, the ear, and the hand of the obstetrician.

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DISCUSSION

DR. JOSEPH F. ELWARD (Washington, D. C.): Dr. Jacobs' paper is a masterly, comprehensive presentation and I wish to sincerely congratulate him on his effort.

Radiography of the pelvis is as old as the discovery of roentgen rays and while interest has seemed to wane at times, there is a definite, unbroken thread of investigation from 1896 to the present time. The Golden Age of research in this field commenced with the work of Thoms, in 1922, and is steadily progressing to a culmination which appears to be not too far in the distant future and will be reached when absolute measurements of the maternal pelvis and fetal head can be accurately determined.

While it is important that both of these structures be carefully studied, the more important is the maternal pelvis. The birth canal is a tortuous fixed passage; the fetus is an adaptable passenger. It would seem, therefore, that the fixed passageway, rather than the adaptable passenger, should be given the first consideration.

Dr. Jacobs quotes Bartholomew as stating that he (Bartholomew) obtained positive roentgen evidence of a fetal skeleton in one-third of his cases at five months, one-half at six months, and almost constantly thereafter. I cannot agree with this statement. To be unable to demonstrate 100 per cent of fetal skeletons at six months is little short of a diagnostic crime, and it is no more than an even wager to say that 100 per cent may be demonstrated at the completion of the fourth month and many considerably earlier.

I now present slide No. 1 (see Fig. 1, Dr. Jacobs' paper). The last menstrual period was May 16. First contact was May 31. Film made September 1. Duration of pregnancy cannot exceed 93 days, or three lunar months plus nine days.

Slide No. 2 (see Fig. 2, Dr. Jacobs' paper). The last menstrual period was January 3. The first contact was January 18. The film was made May 9. The pregnancy, therefore, cannot exceed 112 days, exactly four lunar months.

The original films of these and several other cases are available for study by anyone interested.

The essayist mentions the intra-uterine use of opaque media as a diagnostic procedure and advises caution. I wish to emphasize the admonition, as I am unalterably opposed to the invasion of any pregnant uterus for any purpose except as a life-saving measure. A life-saving measure situation is rare indeed. A routine diagnostic procedure is never justified.

The author has pointed out the fallacy in the roentgen signs of fetal death and mentions fetal age determination by the stage of development of ossification centers. These show considerable variation, and approximate age determinations only are the rule. The experienced obstetrician should be able to do quite as well by simple palpation.

The various methods of roentgen pelvimetry (and Dr. Jacobs has briefly discussed nine such) may be compared in a general way to the old "saw" that when there are many different remedies for a disease, none of them is of great value. I do not mean that the work done should be discarded or ignored, as anything added to the sum total of human knowledge is not lost, but I wish to emphasize that we must recognize the limitations of roentgen pelvimetric methods and be aware of any simpler obstetric procedure that will give us favorably comparable results.

Nor should we forget that all physicians who refer obstetric patients to us for roentgen consultation are not skillful, highly trained obstetricians. Time will not permit any discussion of the nine methods considered by Dr. Jacobs. All have some advantages. None is ideal.

The author's method of determining pelvic measurements in which he takes into consideration the inclination of the plane of the superior strait seems to be the most nearly accurate of the methods for this particular phase. All the methods for determining the size of the fetal head have practically the same fault; that is, inaccuracy because of distortion and inability to precisely determine the exact plane in which the head lies and to adequately compensate for the distortion. The methods using volumetric content as a basis are or may be fallacious in certain particulars, as Dr. Jacobs has told us.

We, as roentgenologists, can give valuable information to the obstetrician and the value to him will be in direct proportion to his knowledge and skill in his chosen field.

THE VALUE OF HYSTEROSALPINGOGRAPHY IN GYNECOLOGIC DIAGNOSIS[1]

By ALBERT MATHIEU, M.D., *Portland, Oregon*

THE modern urologist or gastro-enterologist would have great difficulty in practising with any degree of success without the use of opaque materials and the roentgen ray. The same difficulty confronts the gynecologist in making a finished diagnosis, in predicting prognosis, and in accomplishing proper treatment if he deprives himself of the use of hysterosalpingography. Many of the pathologic conditions with which the gynecologist must contend involve the cavities and linings of the uterus and tubes, and hysterosalpingography offers the best and simplest means of locating and estimating extent and severity of these conditions. The day has passed when one needs guess as to the condition of the internal os, the condition of the endometrium, the size and contents of the uterine cavity, and the patency of the tubes.

My first impression of the method was that it had limitless possibilities for the elucidation of gynecologic diagnosis, but that it might present serious dangers. Increased experience, however, has allayed my fears and convinced me that hysterosalpingography, when properly executed, is safe, easily performed, a minor procedure from the patient's standpoint, and of the utmost value in a certain number of difficult gynecologic studies.

The contra-indications are active, serious infection of the genital tract and normal pregnancy. It is obvious that strict aseptic and antiseptic precautions should attend the injection, and that the greatest care should be exercised in carrying out the various steps of the procedure. The maneuver is harmful when it is improperly or carelessly done, and dangerous if certain contra-indications are not observed; it is unsuccessful if improper instruments or poor oil are used, and useless if one cannot read the films correctly. In over 1,200 injections of iodized oil into the uterus and tubes, I have had no catastrophies and no untoward results to be regretted.

The technic may be made very simple or very involved. There is no need for a manometer, with its long tubing, or other complicated instruments which are difficult to manipulate, and there is no need for hospitalization of the patient. By using the technic herein described, one can complete the maneuver in approximately two minutes, with a maximum of results and a minimum of discomfort to the patient.

The patient is placed in lithotomy position over a Bucky diaphragm at the end of a table which has stirrups. A good light reflected into the vagina is necessary. A vaginal speculum is inserted, and the vagina and cervix are cleaned of discharge. Tincture of iodine is applied to the cervix and to the external os. The anterior lip of the cervix is then grasped with a single tooth volsellum to hold it in a fixed position. The oil-filled, short-tipped cannula, attached to the syringe, is inserted into the external os, pressing the acorn of the cannula gently against its opening, and the oil is injected slowly into the uterine cavity. When the cavity is filled, the oil will proceed into the tubes if they are patent. At this time the patient will experience painful uterine contractions, and the oil will leak backward between the acorn of the cannula and the cervical opening. The amount of oil required for the injection is usually from five to eight c.c. (more, however, if the uterine cavity is large, and less if it is small). The amount of pressure used in the injection should be scarcely more than that used

[1] Presented before the Radiological Society of North America at the Twenty-second Annual Meeting, at Cincinnati, Ohio, Nov. 30–Dec. 4, 1936.

in giving any injection through a syringe. By observing this precaution there can be no danger of excessive pressure. Once the cavity is filled, the roentgenogram is made with the cannula still in position; then the cannula is removed and the oil is allowed to run from the cervix. This completes the injection which, with exposure of the film, usually takes two minutes after the vaginal speculum has been inserted. By using the short-tipped cannula (Fig. 1-*A*) the position of the uterus or the direction of the canal need not be known, and sounding of the uterus is unnecessary since the short-tipped cannula does not extend to the internal os.

Fig. 1-*A*. Short-tipped cannula.

Fig. 1. Hysterosalpingogram of normal uterus and tube. Note triangular shape of uterine cavity without filling defects, normal proximal two-thirds of tubes, and dilated distal ends with partial spill of oil.

It is always well to describe the technic to the patient, and to advise her that she will be told in advance of each pain—that associated with the grasping of the anterior lip with the volsellum, that associated with the insertion of the cannula, and that associated with the filling of the uterine cavity. When she is so advised, and is told further that the entire procedure will be over in two minutes, her discomfort is lessened, anticipation of severe pain is prevented, and co-operation is assured.

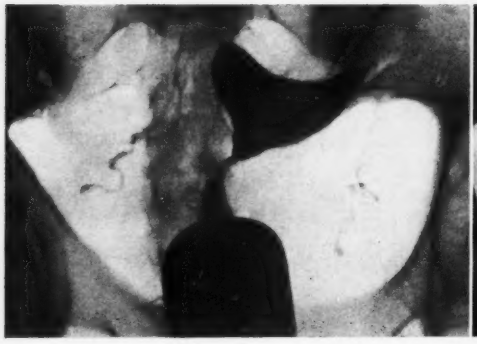

Fig. 2.

Fig. 3.

Fig. 2. Stricture of the internal os.
Fig. 3. Localized hyperplasia in the region of the internal os.

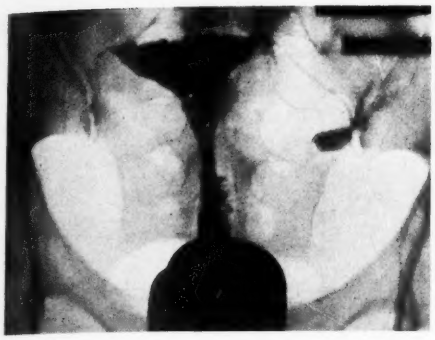

Fig. 4. Generalized hyperplasia of the endometrium.

Fig. 5. Filling defect caused by polyp of the uterine cavity.

Another roentgenogram should be taken from eight to 24 hours later if one wants to know about the patency of the tubes. By this time the tubes and uterus will be empty of the oil, and if the tubes are patent there will be some filmy traces of oil in the pelvic cavity. In the cases in which the tubes are closed, the actual site of the closure will be seen—in the cornu, in the tube proper, or at the distal extremity. All the cavities of the uterus and tubes reached by the oil will be visualized with the roentgen ray.

NORMAL CERVICAL, UTERINE, AND TUBAL CANALS

While all uterine and tubal canals are different, there can be established, more or less, a normal standard (Fig. 1). The uterine canal is usually distinct in outline and triangular in shape. It has a definitely opened cervical canal and no filling defects. A tube—rather tiny and tortuous, but distinctly outlined and dilated at its distal third—extends from each upper horn of the uterine cavity. When sufficient oil is injected, one can see some slight spilling of the oil from the dilated distal ends. However, the diagnosis of patency of the tubes must rest on a second plate, taken from eight to 24 hours after the injection. The presence of a filmy deposit of oil scattered in the pelvis is necessary in making a diagnosis of patency of the tubes.

CERVICAL CANAL

Kinks, obstructions, growths, dilatations,

Fig. 6.

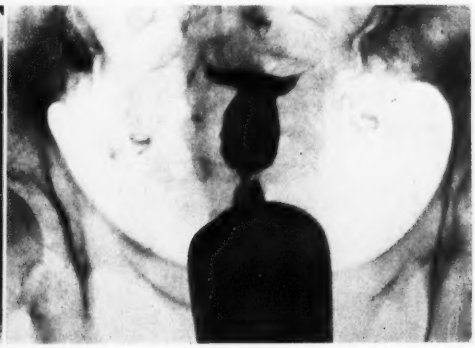

Fig. 7.

Fig. 6. Polyp of the uterine cavity projecting down from the fundus.

Fig. 7. Several small fibroids on the posterior surface of the lower segment of the uterus, causing bulging and dilatation of the lower segment of the cavity.

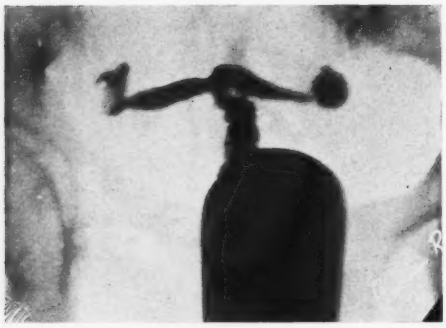

Fig. 8. Bicornuate uterus. Roentgenogram made vertically through the fundus.

Fig. 10. Missed abortion in horn of bicornuate uterus. Aschheim-Zondek test negative.

and stenoses of the cervical canal and internal os are visualized (Fig. 2). The visualization of the actual size, shape, and form of the cervical canal is of great importance in the diagnosis of dysmenorrhea, sterility, and bleeding. Frequently a severe obstruction is found when it is not suspected clinically, and it is not uncommon to have demonstrated a localized hyperplasia of the endometrium just above a stricture or stenosis of the cervical canal. This localized hyperplasia, whether due to improper drainage or to infection, might frequently be the cause of menorrhagia or metrorrhagia (Fig. 3).

UTERINE CAVITY

The size, shape, and position of the cavity of the uterus are shown. Growths in the cavity, or those bulging or pressing into the cavity, can be observed. The condition of the endometrium is usually made plain, so that hyperplasia, either generalized or local, can be seen (Fig. 4). Polyps, carcinomatous growths, or placental débris are demonstrated by more or less characteristic filling defects (Figs. 5, 6, and 7). In visualizing the uterine cavity in the presence of a large myoma, the use of a small lead wire (fitted on the abdominal wall around the contour of the tumor, so that when the roentgenogram is made the lead wire will outline a considerable part of the tumor and the shadow of the iodized oil in the uterine cavity) will show the relationship between the tumor mass and the cavity of the uterus. Double uterus, in all its various forms, and other

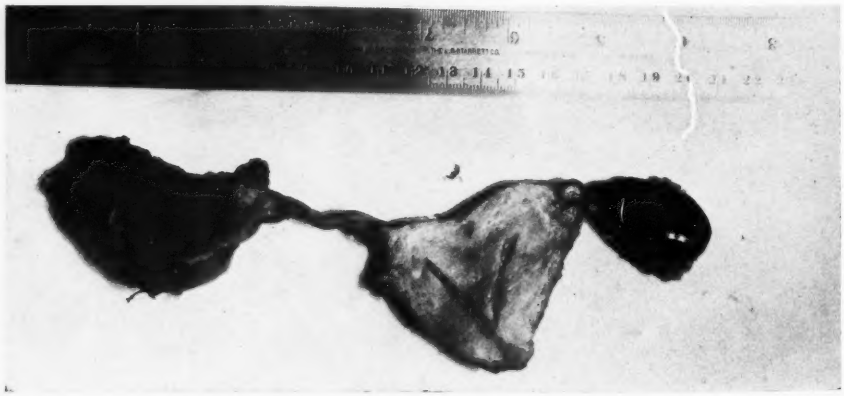

Fig. 9. Sagittal section through uterus and tubes of Figure 8.

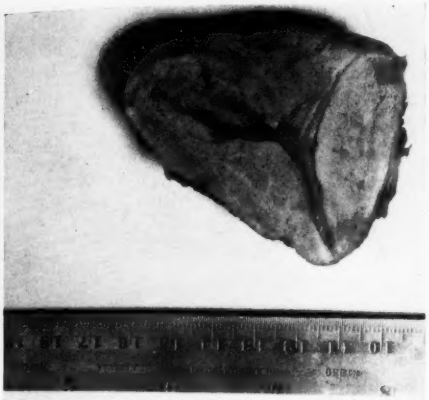

Fig. 11. Sagittal section through bicornuate uterus containing missed abortion in horn of Figure 10.

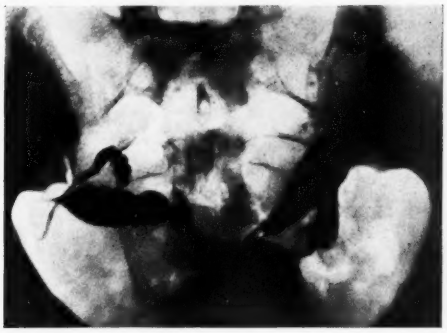

Fig. 12. Double uterus. Patient had two vaginæ and two cervices. Note evidence of bilateral hydrosalpinges.

congenital anomalies, can also be clearly outlined (Figs. 8, 9, 10, 11, and 12).

Iodized oil and roentgen ray have been used in the diagnosis of abdominal pregnancy. Oil visible in the small uterine cavity proved definitely that the pregnancy was not in the uterus.

I have been able to establish what appears to be a pathognomonic sign for certain cases of adenomyoma of the uterus. In those cases in which there is an infolding of the endometrium in such a manner as to make long, cryptic tubes, dipping deeply into the myometrium, the iodized oil will penetrate these cryptic tubes which will then be beautifully visualized. This is the only situation wherein oil can be seen penetrating a myometrium in this characteristic manner (Fig. 13).

TUBES

Patency or non-patency of the tubes can be established, and in case of closure, the site of the obstruction can be localized. The position of the tubes can easily be seen—one can see whether they are hanging low in the pelvis or attached at some high point, whether they are exceptionally tortuous or kinked, and whether they are normal in size and contour. The normal tubal cavity will have a characteristically fuzzy appearance, while the cavity of the tube that is chronically diseased will have a sharply outlined, wiry appearance (Fig. 14). The condition of the tubal cavity, or its position, is frequently of clinical significance. In differentiating between a tubal mass and an ovarian mass, one can readily see that if the tube fills normally to its distal end it can be excluded as a source of the mass.

Small hydrosalpinges which cannot be detected with bimanual examination are often revealed by hysterosalpingography. In about 50 per cent of these small hydrosalpinges the cornual ends of the tubes are open and allow oil to enter, and the configuration of the tubes shows in a characteristic manner. In the film taken at the time of the injection, the tubes show a dilatation of their distal third from three to four times the normal, there is no evidence of spilling, the oil seems to be contained in well-outlined sacs in the ends of the tubes, and the proximal two-thirds of the tubes appear to be normal (Figs. 15 and 17). The 24-hour film shows the uterus and the proximal two-thirds of the tubes empty and clear of iodized oil, and the shadows of the distal ends of the tubes the same as they were the day before (Figs. 16 and 18). If another film is taken a week or two later, the same bags, or shadows, unchanged, will be seen. These shadows of the iodized oil

Fig. 13.

Fig. 14.

Fig. 13. Adenomyoma of the uterus. Note iodized oil in crypts formed by infolding of endometrium into the myometrium.
Fig. 14. Note the wiry appearance of chronically diseased tubes with the absence of normal distal dilatation.

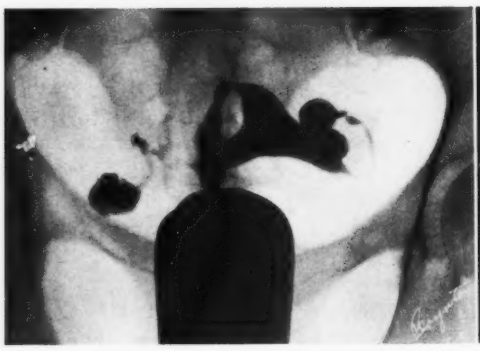

Fig. 15.

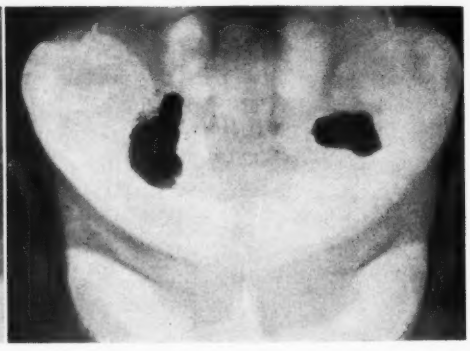

Fig. 16.

Fig. 15. Bilateral hydrosalpinges. Note sacculated dilatation at extreme end of each tube.
Fig. 16. Film taken 24 hours after Figure 15. Note bags of oil.

Fig. 17.

Fig. 18.

Fig. 17. Bilateral hydrosalpinges. Note sacculated dilatation at end of each tube.
Fig. 18. Film taken 24 hours after Figure 17. Note iodized oil retained in sacculated ends of tubes.

Fig. 19.

Fig. 20.

Fig. 19. Ectopic pregnancy aborting from the distal end of right tube. Note how oil drapes itself about the aborting mass.

Fig. 20. Ectopic pregnancy aborted from distal end of left tube. Note how oil drapes itself about the aborted mass.

in definite, unchanging form are a pathognomonic sign of hydrosalpinges. Since the condition is usually bilateral, one sees in the 24-hour film the shadows of two bags of iodized oil hanging down, one in each side of the pelvis. The emptying of the tube in a case of hydrosalpinx is different from the emptying of a normal tube. The iodized oil in that portion of the tube which still possesses a good muscular layer is evacuated into the uterus by peristaltic waves, while the iodized oil contained in the sac remains there, because the musculature in this portion of the tube is so thinned out that it cannot function.

There is still another sign which is characteristic of hydrosalpinx as visualized with iodized oil and the roentgen ray. Often when the oil enters the tube, it drops into the sacculated portion containing the serous fluid, mixing with this fluid and forming a rather coarse emulsion, and the shadow on the film shows many droplets of iodized oil in the fluid in the sac. There is one possible source of error in reading this sign. The droplets may also be seen when oil spills through the distal end of the tube and falls into free fluid which may be present in the pelvis or in the cul-de-sac. This happens rarely, but when it does, the droplets are seen low down in the pelvis, near the midline, and do not appear contained in a sac, and the 24-hour film will show this oil disseminated throughout the pelvis. If this emulsion is contained in the tubal end, it will still be there on the 24-hour plate as a bag of oil, not as an emulsion, and will not show the droplet sign.

In all cases where plastic operations have been done on the tubes for the purpose of correcting sterility, the results of the operation can eventually be checked by the use of hysterosalpingography, so that one can determine whether or not the operation was a success.

ECTOPIC PREGNANCY

I have used hysterosalpingography in several cases of tubal pregnancy as an aid in diagnosis and have obtained practically 100 per cent correct diagnoses. In tubal pregnancy, aborting from the distal end of the tube, the injected oil enters all the crevices between the aborting pregnancy and the walls of the distal end of the tube in such a way that it literally drapes itself about the mass which can then be visualized by the x-ray (Figs. 19 and 20). In my cases of tubal pregnancy in the midportion of the tube, the injected oil went down to the site of the pregnancy, and, because this site was apparently well sealed off, ended abruptly and showed in a characteristic shadow (Figs. 21 and 22). This also proved quite

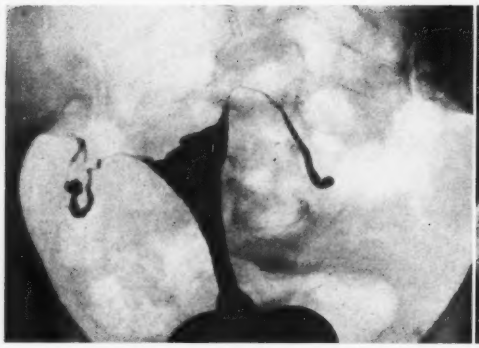

Fig. 21.

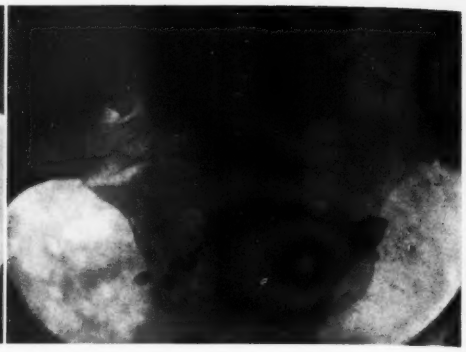

Fig. 22.

Fig. 21. Ectopic pregnancy in the midportion of left tube. Note how tube ends abruptly in a rounded manner just proximal to the tubal pregnancy. Note filling defects at each end of uterine cavity. These are due to filling defects caused by decidua. This roentgenogram does not visualize the ectopic pregnancy. It merely visualizes the characteristic finding in that portion of the tube proximal to an ectopic pregnancy in the midportion of the tube.

Fig. 22. Ectopic pregnancy in the right tube. Note how tube ends abruptly in a rounded manner just proximal to the tubal pregnancy. This roentgenogram does not visualize the ectopic pregnancy. It merely visualizes the characteristic finding in that portion of the tube proximal to an ectopic pregnancy in the midportion of the tube.

conclusively what has long been suspected by many, that the bleeding from the uterus in cases of tubal pregnancy is from the uterine wall and not from the site of the tubal rupture. While I do not advise hysterosalpingography except when it appears necessary to establish the diagnosis, I do feel that the injection of iodized oil into the uterus and tube in a case of tubal pregnancy is practically harmless. When the injection is done carefully and by one experienced in its use, there is no reason to believe that it can do harm. I can present sufficient proof that its use is of the highest value. The least that one can say in behalf of hysterosalpingography is that when both tubes fill well and normally to their distal ends, one can surely rule out tubal pregnancy. I have been able to establish what seems to be a pathognomonic x-ray sign of tubal pregnancies—for those ruptured or unruptured in the midportion of the tubes, and for those aborting from the distal ends of the tubes. I have located the site of tubal pregnancy in 12 patients by means of hysterosalpingography.

CONCLUSIONS

Hysterosalpingography is as valuable and as welcome as visualization of the bronchial tree or the urinary tract. Very few untoward effects have been reported in the literature; most of those that have been reported were due to faulty technic. If one uses good technic and avoids the maneuver in the presence of active infection or normal pregnancy, it offers a maximum of results in diagnosis as pertains to the cavities of the uterus and tubes with a minimum amount of discomfort. It is such a valuable aid in diagnosis that if more hysterosalpingograms were taken, fewer hysterectomies would be performed when curettage would suffice, and fewer curettages would be done when hysterectomy is necessary. Its most valuable field is in the study of sterility, wherein it is important to decide whether or not the tubes are patent, and to determine the position and nature of obstructions. In several of my patients pregnancy followed soon after the injection of iodized oil when this was the only procedure done that might have had a corrective value. In such cases it is reasonable to assume that the tube was actually opened in some way by the process.

To recapitulate, the gynecologist will find hysterosalpingography valuable—

1. In detecting patency or non-patency of the tubes;

2. In the determination and localization of occlusion of the tubes;

3. In the visualization and orientation of the uterine cavity, including the internal os;

4. In the diagnosis of intra-uterine tumors;

5. In demonstrating other abnormalities of the uterine and tubal cavities (uterine subinvolution, infantile uterus, tubal kinks);

6. In the diagnosis and localization of ectopic pregnancy;

7. As an aid in the diagnosis of abdominal pregnancy;

8. In checking the results of plastic operations on the tubes;

9. In determining whether a tube or the uterus in the region of the pelvic mass is or is not an integral part of the mass;

10. As an indication for hysterectomy for fibroids in preference to myomectomy in cases in which the tubes can be shown to be occluded;

11. In the study of dysmenorrhea;

12. In the visualization of hyperplasia of the endometrium;

13. As an aid in the diagnosis of adenomyoma;

14. Finally, and by no means a minor consideration, for didactic and academic purposes.

DISCUSSION

DR. A. DAVID WILLMOTH (Louisville, Ky.): I have listened with great interest to the three papers presented here on a method of diagnosis in gynecologic work. Having been a gynecologist and an abdominal surgeon myself for a number of years, it naturally appeals to me in more ways than one.

And yet I can see there are many disadvantages, perhaps, that the surgeon has to take into consideration in private work over that of a municipal hospital, perhaps, where final reports and where considerations for mortality do not enter into the question.

There were some slides shown here of pregnancies, diagnosed by the intra-uterine method of injecting oil. I would want to be doubly sure, in my State of Kentucky, under our present laws, that I had legal permission to inject this oil before I would attempt it on a case of suspected pregnancy, and even then I think we perhaps would be subject to the woman and her husband coming into court later and saying they did not fully understand the paper they signed.

We would again have to face a court in a case of that kind. That was one of the questions that came to me during the delivery of the Symposium.

Another Speaker, in stating his subject (I think it was Dr. Randall, from the Mayo Clinic), said that you must be doubly sure the tube was closed; if not, they'd name the baby for you. I do not know of any method we have of knowing how long those tubes would remain closed, even though we did determine definitely that they were closed at that time, and to tell the woman that she would be forever sterile would be taking in a great deal of territory.

I could cite you a case in my town of a legal contest in which the court was told the woman was sterile. The case went to the Court of Appeals on a large judgment and before the verdict was handed back down she presented the husband and the court with a nice girl baby.

So I do not know just how long tubes remain closed because Nature will open any tubal canal that is humanly possible to be opened. We know that. You can't close the pylorus of the stomach, for instance, and keep it closed even though you put a silver clamp on it. Nature will open it in such a manner that it will permit food to pass through—she is determined to do all she can for the patient. In that way a tube that is closed to-day may not be closed in two or three months from now.

I would like to ask the Speakers, in closing, how they determine, for instance, the following: You have a tube that is open, that permits gas and oil both to pass through, and then has behind it or surrounding it adhesions that are really giving the patient trouble. Does roentgen examination give any particular information over that which could be obtained by a bi-manual examination, pertaining to a pregnancy that is very much desired?

I have a number of patients under observation now, concerning whom that is true. There are so many other variable factors—the husband, for instance,—the various hormones, chemical conditions within the cervical and uterine canal—that all have to be taken into consideration. Even if we determine the tubes are patent, are we very much better off?

Dr. Albert Mathieu (closing): One of the greatest difficulties we have when talking about things that are either new or strange is that we are so constantly misunderstood. I think I very carefully said that normal pregnancy was a definite contra-indication to this method of diagnosis.

The fact that I showed a pregnancy here does not mean anything to the contrary. This woman was about to be aborted for some other purpose, and this film was taken purely in an academic way. We still say that normal pregnancy is a contra-indication.

Neither do we attempt to show that hysterosalpingography is a panacea for all diagnostic ailments in gynecology. It is not. It merely visualizes the cavity of the uterus and tubes to the point where the oil will go. That is all it will do.

We think the method is quite harmless, and in over 1,200 injections that I have done myself or supervised there has been no catastrophe and no regrettable result.

It is obvious, of course, that if the contra-indications are not observed, if improper medium is used, if improper instruments are used, or careless technic is performed, the method can be harmful and can be dangerous. But there is no need for any hulaballoo about it at all because we know it is quite simple and instances of untoward results are minor and few, compared to the sum total of the benefit evolved.

When I spoke at Cleveland the other night before the Clinic of Dr. Crile, Jones reported 12 cases of pregnancy within three months after the injection.

I do not mean to say it has any value as treatment, although I could understand how the injection of oil might unseal the distal end of the tubes to the point where penetration of the spermatozoa could obtain.

Dr. Lawrence M. Randall (closing): I have just a few things I would like to say in closing. One is that out of these 600 patients I injected with iodized oil, there were three (and we followed these patients very closely) in whom there was evidence of pelvic inflammation following the injection of the oil. In all of these patients the diagnosis that was made at the time of injection was chronic salpingitis with tubal occlusion, and we did not find any evidence of iodized oil in the peritoneal cavity.

In other words, we simply caused an exacerbation of an old inflammatory condition.

I do not propose to go into the technic or the contra-indications except to say that every care is given these patients to safeguard them from the sequelæ, and in the patients we have seen I am sure the methods, both of them, have been of definite benefit to the patient with a risk so small that you can disregard it.

Dr. Peirce mentioned the question of oil being left in the tubes. I have a patient I have been following for two and a half years, whom I injected, who still has some opaque material in her tubes, without any symptoms. The material is almost as radiopaque as it was when I put it in.

I believe there is definite therapeutic benefit to be considered when you do either a tubal insufflation or an iodized oil injec-

tion. Of course, there are many factors that we do not know about when we get to talking about sterility. Nevertheless, —and this has been borne out, I think, in many places—somewhere between 15 and 20 per cent of sterile women in whom one does not find any evidence of disturbance of physiology or pathologic change, will conceive in the third or fourth month succeeding the injection.

I have never told any woman that she absolutely could not get pregnant. If the diagnosis of tubal occlusion is made, the prognosis to the patient is definitely softened, because I quite agree with the Doctor from Louisville that one should not as a rule give a definitely unfavorable prognosis. Obviously, anybody who sees sterile women does not depend upon this particular phase of the thing to give a final diagnosis as to the particular case.

We all recognize that there are many other factors beside this. However, if a patient comes to you complaining of sterility, you have to demonstrate that she has patent tubes or all your other therapeutic measures will have been of no avail.

I would like to emphasize just one other thing and that is this question of what we have called "physiological resistance." I have so frequently seen it lead to an erroneous diagnosis that I believe it should always be kept in mind, until excluded, so that we do not make the mistake of making a diagnosis of non-patent tubes in cases in which the failure of the medium to pass is based purely on the physiologic and not the pathologic condition.

DR. R. A. ARENS (closing for Dr. Stein): Answering Dr. Peirce's question as to how much gas is employed in pneumoperitoneum, it has been our custom to use 1,000 c.c., either by the intra-uterine or transabdominal route.

Why some individuals absorb gas much more readily than others is very difficult for me to say. In the past I have seen air remain in the peritoneal cavity for as long as 30 days, whereas in the average normal individual at least from 90 to 95 per cent would be absorbed within from 48 to 72 hours.

The gas we prefer is carbon dioxid. The absorption is approximately 80 per cent in 20 minutes, so that if you fail to get the films you desire immediately after pneumoperitoneum is induced, you have no recourse but to repeat.

We have found one thing of interest, that even using the same container of carbon dioxid for some period of time, the gas apparently changes somewhat, so that it fails to absorb so rapidly. Whether it is because of a chemical reaction of the gas with the metallic chamber of the container, I do not know.

As an indication of what might happen in the gas container, the following may be of interest: the manometer that we employ, to determine the amount of gas used, is made of glass. On one occasion we broke off a little arm and, naturally, this was immediately sent to the glass blower, to have a new arm put on. He was quite surprised that he could not repair it because the moment he put the glass in the flame it cracked and chipped, but would not fuse or melt. It chipped and kept on chipping until the arm was broken off to the main chamber and there was nothing left to do but to make a new one. The character of the glass undoubtedly was changed by this contact with the gas. So it may be that carbon dioxid in a metal tank may change its character somewhat so that after a period of time the absorbing qualities are altered. Therefore, we have made it a policy to change our gas containers with comparative frequency.

CARCINOMA OF THE BRONCHUS[1]

By LOUIS H. CLERF, M.D., *Philadelphia*

THE remarkable disproportion between the largenumber of reported cases of primary carcinoma of the bronchus and the small group that have been successfully treated suggests that an inquiry be made to ascertain its causes. It is generally recognized that roentgenology and bronchoscopy have aided immeasurably in the diagnosis of bronchial carcinoma. With recent advances in thoracic surgery, lobectomy, even pneumonectomy in selected cases, are considered as relatively safe procedures. Improvement in equipment and technic in the employment of the roentgen ray and radium in therapy gave the hope that relief would be secured by these agents. The meager reports of cases cured by any kind of radiotherapy would seem to indicate that the only satisfactory treatment at present is surgical extirpation. There are many factors that bear on the problem of surgical treatment of carcinoma of the bronchus. Many growths are so located anatomically that surgical removal is not compatible with life. Carcinoma is commonly observed after the fifth decade of life, a time when risks incident to surgery of the lung are greatly increased. There remains, however, a large group of patients who could be treated surgically were it not for the fact that the diagnosis is made late and the growth is too extensive. It would appear, therefore, that the most important reason for the disproportion between the reported and the successfully treated cases of carcinoma of the bronchus is delay in diagnosis.

If there is to be any advance in the surgical treatment of bronchial carcinoma, it will depend almost entirely upon arriving at a correct diagnosis early in the disease. This responsibility rests primarily with the clinician who usually is the first to be consulted by the patient; however, the roentgenologist and the bronchoscopist must share a part of the burden for they too are called upon to aid in the diagnosis. The clinician should be "cancer of the bronchus-minded" as well as "roentgen-ray-minded." He should also appreciate the importance of endoscopic examination in cases of obscure chest signs and symptoms. In addition, he should realize that when cancer is a diagnostic possibility it is important to arrive promptly at a diagnosis.

Certain of the diagnostic aspects of carcinoma of the bronchus will be considered. It is not intended to present a detailed account of the symptoms and physical signs of bronchial carcinoma; however, the roentgenologist as well as the clinician should be familiar with these. Of vast importance in bronchial carcinoma as in carcinoma elsewhere is the ability to recognize its early manifestations.

Clinical Considerations.—No group of symptoms or signs can be considered as diagnostic of carcinoma: they are dependent on the location of the growth and its influence upon adjacent structures. The early symptoms are important as the correct interpretation of these will lead to early diagnosis. A diagnosis made when the carcinoma is advanced is of statistical value only; from the patient's standpoint it is of little or no importance. This was well stated by Tuttle and Womack (1): "In the diagnosis of cancer any method that requires metastasis before it can be utilized may as well be discarded so far as the welfare of the patient is concerned." A statistical study of cases reported in medical literature and of records at the Bronchoscopic Clinic, Jefferson Hospital, indicated that cough with or without sputum was the most common early symptom of carcinoma involving the larger bronchi. Cough is the result of bronchial

[1] Presented before the Radiological Society of North America at the Twenty-second Annual Meeting, at Cincinnati, Nov. 30–Dec. 4, 1936.

irritation, often is persistent, frequently fails to respond to treatment, and often interferes with sleep. If associated with blood-streaked mucoid sputum, in the absence of tuberculosis, it is highly suggestive of bronchial neoplasm. Profuse purulent expectoration in cancer is indicative of extensive bronchial infection, the result of bronchial obstruction with retention of secretions. It cannot be interpreted as an early symptom. Hemoptysis may occur early or late and varies in amount from slight streaking to frank hemorrhage. A large blood loss, however, is usually a late manifestation.

It is interesting to note that wheeze as a symptom of early cancer is not often mentioned in the medical literature (2 and 3). One observes, however, that asthma often is considered as a diagnostic possibility (Fig. 1). Wheeze is a common symptom of partial obstruction to a bronchus. It is not continuous, being influenced by cough and deep inspiration and often is not noticed by the patient. It is best heard during and at the end of expiration when the bronchus normally becomes narrowed. A wheeze, taken in conjunction with cough and occasional blood-streaked or no sputum, constitutes very strong evidence of newgrowth producing early partial obstruction to a bronchus.

Pain is not a common early manifestation of carcinoma originating in the larger bronchi. It is, however, considered as "the most common signal symptom" of peripheral carcinoma and is due to peripheral extension of the growth to the pleura and extrapleural structures (4). There may be an associated area of tenderness. Dyspnea, pleural effusion, weight loss, weakness, fever and sweats, dysphagia, hoarseness, pupillary changes, and engorgement of the veins of the neck and chest are commonly evidences of advanced disease and are principally of didactic interest.

Radiographic Features.—Hruby and Sweany (5) expressed the opinion that "perhaps no other one factor has been so important as the roentgenogram in contributing to the changed attitude toward cancer of the lung." In 1932, Manges (6) stated that the diagnosis of cancer, as a rule, is not made until the lesion is well advanced. He found that the vast majority of the proved cases showed either a large tumor mass, atelectasis of a lobe, or a large area of exudate-filled lung distal to an obstructing growth. In a study of a group of 50 cases of bronchial carcinoma, Farrell (7) observed that atelectasis was the most common radiographic finding. These observations indicate that the roentgenologist sees patients late, when the disease is sufficiently far advanced to obstruct bronchi and interfere with drainage of secretion and when suppuration is present distal to the obstruction. This need not

Fig. 1. Film made in the case of a man, aged 54 years, who gave a history of perennial hay fever for past five years. In 1935 the hay fever symptoms did not clear up. Cough, wheezing, and shortness of breath persisted; later, sputum became blood-streaked. This case was treated as a case of bronchial asthma for eight months. The roentgenogram revealed heavy root shadows, more marked on the left side. Bronchiectasis was suspected and lung mapping was recommended. At bronchoscopy there was found a neoplastic lesion in the left lower lobe bronchus. Histologic examination of tissue removed was reported by Dr. B. L. Crawford as squamous-cell carcinoma. (Film by Dr. J. T. Farrell, Jr.)

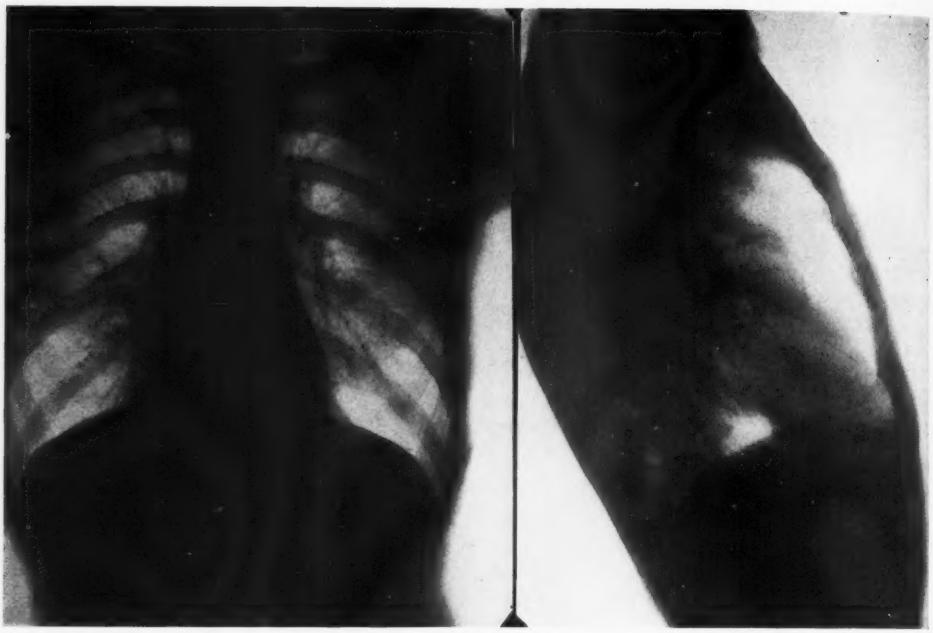

Fig. 2. Roentgenograms made in the case of a man, aged 48 years, who complained of cough of one year's duration. Recently there had been expectoration and pain over the lower chest in the midline. The roentgen appearances suggested an inflammatory process although neoplasm could not be ruled out. At bronchoscopy, there was found a pale granular mass obstructing an inner subdivision of the right lower lobe bronchus. Tissue secured was reported as squamous carcinoma by Dr. B. L. Crawford. (Films by Dr. R. Manges Smith.)

necessarily be a cause for pessimism. If one will recall that prior to 20 years ago a majority of cancers of the lung were diagnosed in the autopsy room, one should be optimistic. Difficulty in diagnosis is met with in the group of cases in which the findings are suggestive of tuberculosis, pneumonitis, bronchiectasis, or pulmonary abscess without roentgenographic evidences of tumor or bronchial obstruction (Fig. 2). In these, one must exhaust all of the diagnostic means at hand to bring the case to a final diagnostic conclusion.

Since over 50 per cent of primary bronchial neoplasms originate in the larger bronchi, it is evident that in many during the early stages there is partial obstruction to a bronchus, with obstructive emphysema. It should be recalled that one cannot always demonstrate partial obstruction of a bronchus by the examination of stereoroentgenographic films, which usually are made at the end of full inspiration. Roentgenoscopic examination of the chest and a study of the films made at the end of full inspiration and expiration aided greatly in the recognition of nonopaque foreign bodies in the bronchus and a knowledge of the mechanism of obstructive emphysema. Such a plan of study should be employed routinely in the examination of suspected cases of early primary carcinoma of a bronchus before the growth has progressed to complete bronchial obstruction with atelectasis.

Bronchoscopy.—"Next to its usefulness in the removal of foreign bodies from the air passages, bronchoscopy has developed its greatest value in the diagnosis of malignancy of the lung" (8). Bronchoscopy is the most definite and positive diagnostic procedure available. One may obtain a direct endoscopic view of the growth; in addition, tissue may be secured for histo-

logic examination. If no intrusion of growth into the bronchus can be visualized, one may observe evidences of infiltration of the bronchial wall, namely, fixity and rigidity. It must be borne in mind, however, that the bronchoscopist can examine and explore only the larger bronchi; no opinion can be given concerning the smaller bronchial subdivisions. One would, therefore, secure little or no information from bronchoscopy in cases of peripheral cancer; in lobar atelectasis, however, the location and nature of the obstruction could be readily visualized.

Data concerning the anatomical location of primary bronchial carcinoma vary greatly, observers reporting from 35 to 75 per cent of growths as having their origin in the larger bronchi. The number of cases of carcinoma diagnosed positively by bronchoscopy and biopsy also varies—obviously, this depends upon the type of case selected for bronchoscopic study. If performed in cases of atelectasis or in advanced carcinoma only, the number of positive diagnoses would be nearly 100 per cent. If, however, one examines routinely all suspected cases of newgrowth, the number of positive diagnoses is considerably less. At the Bronchoscopic Clinic, of a group of 143 cases of primary carcinoma of the bronchus proven by examination during life or at autopsy, 98 were diagnosed positively by bronchoscopy and biopsy. In three cases an exploratory thoracotomy was performed and tissue secured. Five were diagnosed as pulmonary abscess and drained surgically. Carcinoma was discovered at operation or by biopsy of tissue from the cavity. In 23, newgrowth was strongly suspected from the bronchoscopic findings of bronchial stenosis with fixation and rigidity of the bronchial wall: no biopsy was secured. The diagnosis of cancer ultimately was made either by repeated bronchoscopic examination or at autopsy. In 14, the bronchoscopic findings were inconclusive and the diagnosis of cancer finally was made at autopsy. In the cases proven by bronchoscopy, the growths originated in the larger bronchi and were readily accessible for inspection and biopsy.

In those cases without intrusion of growth into the larger bronchi, repeated bronchoscopies will ultimately lead to a positive diagnosis. Metastases also will give conclusive information. If the factor *time* is not taken into consideration in arriving at a diagnosis of cancer, then the most conclusive diagnostic method would be a postmortem examination. However, if one considers carcinoma of the bronchus from the standpoint of surgical extirpation, delay in diagnosis cannot be endured.

Of the group of 143 cases observed, not more than five could have been considered as suitable for surgical treatment at the time bronchoscopy was done. This conclusion was arrived at on the basis of the location and extent of the growth and the age of the patient.

Lung Mapping.—The employment of iodized oil (40 per cent) to visualize the bronchi is of value in those cases in which no conclusive information can be secured by bronchoscopy. This diagnostic aid cannot supplant bronchoscopy if it is possible to visualize the lesion endoscopically. These usually are cases of upper lobe lesions or peripheral tumors which cannot be visualized by direct examination. Retained secretions in the smaller bronchi may interfere with proper filling and be a source of error.

Comment.—Collected data concerning cases of carcinoma of the bronchus show conclusively that the diagnosis is commonly made late in the disease when surgical treatment can no longer be considered. In a large number, probably a majority of these, the diagnosis could have been made early if there had been an opportunity to carry out all of the recognized diagnostic procedures. The clinician should consider bronchial carcinoma as a diagnostic possibility and should carefully interpret the early symptoms, such as cough without or with sputum, blood-streaking, pain, and wheeze. The symptoms of advanced disease should not be waited for. Radiographic studies should be secured early.

The roentgenologist should be conversant with the clinical history and the symptoms. Examination of the chest should include a study for obstructive emphysema.

The bronchoscopist should be given an opportunity to investigate endoscopically all cases of obstructive emphysema or obstructive atelectasis. Unexplained cough, hemoptysis, and wheeze also warrant bronchoscopy. Iodized oil instillation should be employed as a supplementary aid. Above all, there should be close cooperation between the clinician, roentgenologist, and bronchoscopist. In cases with unexplained pathologic findings, the thoracic surgeon should be consulted.

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DISCUSSION

DR. LEO G. RIGLER (Minneapolis, Minn.): Dr. Clerf has presented in clear and concise form the picture of the present status of carcinoma of the bronchus as a medical problem. I can agree thoroughly with all he has said about the vital importance of the early recognition of this disease.

Twenty years ago carcinoma of the bronchus was not our problem. Pathologists even considered it rather rare, and cases which were diagnosed clinically were very unusual. Ten years ago the diagnosis of carcinoma of the bronchus became a serious problem for the roentgenologist and for the bronchoscopist, but the discussion was largely academic because very little was done about it after the diagnosis was made.

To-day the successes of thoracic surgery, which Dr. Clerf has mentioned, make the positive diagnosis exceedingly important, and with the work of Dr. Clerf and his associates and other work that has been done, we are improving tremendously in our ability to recognize these lesions earlier.

But with this active surgery, a new responsibility and a new problem have presented themselves to us. Whereas before we were largely concerned with the failure to diagnose bronchogenic carcinoma, to-day we may well be concerned with false positive diagnoses, because they may result in drastic surgery which, as all of you know, entails a very serious risk.

In most cases amenable to bronchoscopy, error should occur very rarely. On the other hand, as Dr. Clerf has said, there are cases which are not amenable to bronchoscopy and in which the clinical and roentgenologic findings must decide the diagnosis. In those cases, great care must be exercised so that false positive diagnoses shall not be made.

I would like to show just two cases, merely by way of illustration of this point. In the first one, resection of the rib for empyema was made on this boy before we saw him. He came in with a condition which we interpreted as atelectasis with an obstruction of the lower lobe bronchus. He was bronchoscoped and the bronchoscopist thought that there was tumor tissue in that lower lobe bronchus. Biopsy was made and a diagnosis of carcinoma was obtained from the pathologist. Eventually this was proved to be false and further examination of the tissue indicated its inflammatory nature.

This is not a unique case. There are any number of them that have been reported throughout the country. Fortunately for this boy, the circumstances were

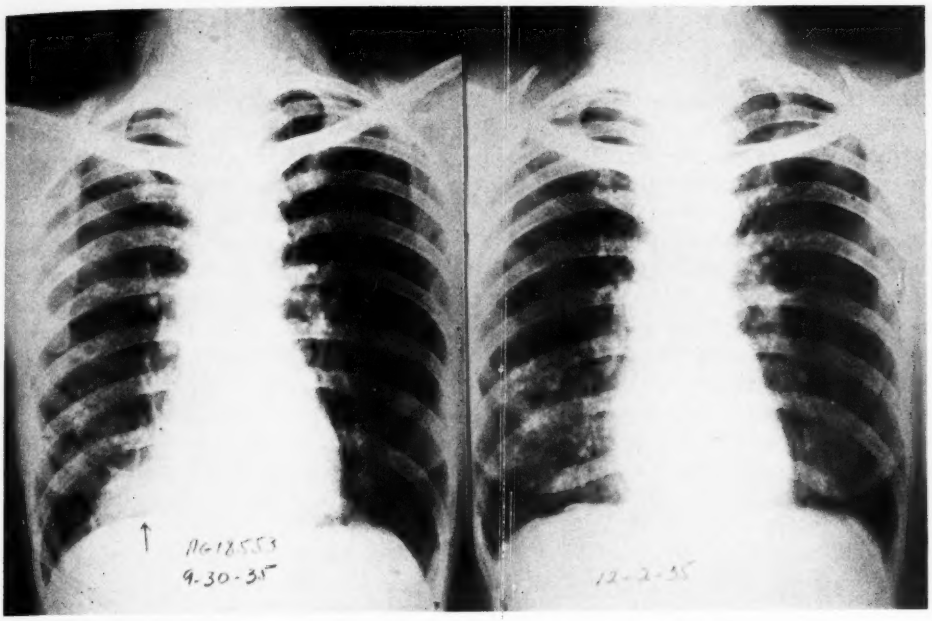

Fig. 1. Fig. 2.

Fig. 1. Roentgenogram of chest made Sept. 30, 1935, with consolidation at right base which had been increasing in size for months. Clinical and roentgen studies were suggestive of peripheral bronchogenic carcinoma.

Fig. 2. Same case, two months later, with almost complete, spontaneous resolution, indicating error in diagnosis. Residue of iodized oil in alveoli is also shown.

such that no effort at surgery was made, but I call attention to it because of the possibility of that type of error occurring. The histologic diagnosis of the bronchial mucosa is not an easy one and it takes a very experienced pathologist, experienced in that particular type of histological diagnosis, to be certain as to his findings. Another film on the same boy a little later, when the bronchus had been opened up and we were able to fill it with iodized oil below the obstruction, demonstrated the typical dilatation which had occurred. It is about five years since that time and he is still alive.

This next case is of a somewhat different type. This was a woman sent in to a tuberculosis sanitorium because of blood-streaked sputum—a diagnosis of tuberculosis had been made. She was studied there over a period of three months. When she first came in to the sanitorium there was a small density in the cardiophrenic angle, very small, perhaps one-third the size of the density which you see in this slide. This was shown in the lateral view to be quite peripheral, in the posterior portion of the lower lobe (Fig. 1).

That area of consolidation grew under our very eyes over a period of about three months during which she had all the symptoms which suggested carcinoma. She was sent in to our hospital, the lesion having attained this size. Being very peripheral, the bronchoscopy was negative, but we considered that of no significance. We felt she had a carcinoma of the peripheral type—a type ideal for treatment. Surgery was recommended but, fortunately for her and for us, she refused it and three months later the lesion had disappeared completely as shown in Figure 2. No doubt this was some type of atypical pneumonia. The woman is perfectly well now.

I cite these two cases to show that some

of these early diagnoses may lead us very far astray.

DR. H. W. JACOX (Pittsburgh): May I ask Dr. Clerf what he does in these cases that he speaks of, the early ones in which the x-ray findings are not very definite, in regard to treatment? In most cases I see, my opinion is asked and I should like to know whether he uses surgical diathermy in these early ones to avoid the serious risk of radical surgery or whether he uses radon seeds. What is his present opinion in regard to treatment—to be as conservative as possible and yet get rid of the cancer?

DR. CLERF (closing): There is no conservative treatment of carcinoma of the bronchus. For a time we believed that destroying the growth by bronchoscopic fulguration would be effective, but a cure by this means would be a curiosity. Unless irradiation therapy can cure these cases, then there is but one plan of treatment, namely, surgical extirpation. If this cannot be practised, the case is hopeless.

PRIMARY BRONCHIAL CARCINOMA AND PULMONARY METASTASIS COMPARED CLINICALLY AND ROENTGENOLOGICALLY[1]

By JOHN T. FARRELL, JR., M.D., *Philadelphia*

From the X-ray Department of the Jefferson Hospital

THE increasing occurrence of primary bronchial carcinoma and the high incidence of metastasis to the lungs makes a comparison of the two conditions of interest. In 1934 the author presented before this Society a study of 78 cases of pulmonary metastasis discovered at necropsy at the Jefferson Hospital in the ten-year period from November, 1924, to November, 1934 (1), and in 1935 a study of 50 cases of primary bronchial carcinoma in which the diagnosis was made by histologic examination of tissue removed from the tumor (2). This presentation is based on re-examination of the material and a comparison of primary and metastatic pulmonary malignancy as to the age and sex of the patients, the initial and general symptomatology, the roentgen signs, the duration and the prognosis.

Histologic Classification.—Of the primary group, 23 (or 46 per cent) were classified as squamous-cell carcinoma, three (or 6 per cent) as adenocarcinoma, and 24 (or 48 per cent) as undifferentiated carcinoma.

The metastatic tumors were secondary to carcinoma in 61 (or 78 per cent), to sarcoma in 12 (or 15.3 per cent), to melanoma of the skin in two (or 2.4 per cent), and to an endothelioma of the pleura, a teratoma of the testicle, or a thymic tumor in one (or 1.2 per cent) each.

Sex (Table I).—Of the primary carcinomas 45 (or 90 per cent occurred in males and but five (or 10 per cent) in females. This is in accord with the findings of other observers.

In the metastatic group 53 (or 67.9 per cent) occurred in males and 25 (or 32.1 per cent) in females. While there is still a much higher incidence in the male, the ratio is reduced from two-to-one as compared with the nine-to-one ratio in the primary group. The explanation of the preponderance of males is not clear, for of the 61 cases of metastatic carcinoma, seven (or 11.4 per cent) were secondary to cancer of the breast in which the incidence in women is much greater than in men. However, the incidence of metastasis of cancer peculiar to women is offset by the higher rate of metastasis to the lungs from primary tumors of the generative organs in males, seven (or 11.4 per cent) were primary in the prostate or testicle as against one (or 1.6 per cent) from the ovary.

TABLE I.—COMPARISON OF PRIMARY AND METASTATIC PULMONARY MALIGNANCY AGE-SEX DISTRIBUTION

	Primary (50 Cases)		Metastatic (78 Cases)	
	No.	Percentage	No.	Percentage
1–10			1	1.2
21–30	4	8	6	7.6
31–40	9	18	11	14.1
41–50	16	32	21	26.9
51–60	15	30	21	26.9
61–70	6	12	10	12.8
71–80			7	8.9
81–90			1	1.2
Males	45	90	53	67.9
Females	5	10	25	32.1

Age (Table I).—As one would expect, the highest age-incidence is found in the so-called "cancer age" which occurs after 40 years. This is true in this series: 31 (or 62 per cent of the primary growths and 42 (or 53.8 per cent) of the metastatic lesions were in patients between 40 and 60 years of age. In the extremes of age, however, the metastatic group showed

[1] Read before the Radiological Society of North America at the Twenty-second Annual Meeting at Cincinnati, Nov. 30–Dec. 4, 1936.

the higher incidence; one tumor was in a patient 20 years of age and eight (or 10.1 per cent) occurred in individuals over 70, whereas, in the primary tumors 46 (or 92 per cent) occurred in patients between the ages of 20 and 70 years. This is probably due to the fact that tumors of the urogenerative organs, responsible for 17 (or 27.7 per cent) of the cases of metastatic cancers, occur relatively late in life.

Symptomatology (Table II).—The striking difference in the two groups is in the incidence of pulmonary symptoms. It would be expected that some form of respiratory symptom due to local bronchial irritation would occur in the primary tumors and that all patients would complain of one or more. This is true. One might also expect that in metastasis respiratory symptoms would occur, but, as a matter of fact, they are not prominent.

TABLE II.—COMPARISON OF PRIMARY AND METASTATIC PULMONARY MALIGNANCY SYMPTOMS

	Primary (50 Cases)		Metastatic (78 Cases)		
	No.	Percentage	No.	Percentage[2]	
Cough	49	98	15	42.8	(2)
Expectoration	34	68	6	17.1	(4)
Pain	30	60	9	25.7	(3)
Dyspnea	27	54	23	65.7	(1)
Loss of weight	26	52			
Hemoptysis	24	48	6	17.1	(5)
Elevated temperature	14	28			
Wheeze	6	12			
Night sweats	6	12			
Hoarseness	3	6	1	2.8	(6)
Dysphagia	1	2			
None			37	47.4	
Not recorded			6	7.6	

[2] Determined on basis of 35 cases presenting respiratory symptoms.

It was definitely stated in the histories of 37 (or 47.4 per cent) of the patients with pulmonary metastasis that there were no local respiratory symptoms, and in six (or 7.6 per cent) neither the presence nor the absence of symptoms were recorded. It may be assumed from this that they were not present, indicating that of the 78 patients only 35 (or 45 per cent) exhibited local manifestations.

Cough, expectoration, pain in the chest, dyspnea, hemoptysis, and wheeze were the most frequently encountered local symptoms of the primary group. Dyspnea, cough, pain, and expectoration, in that order, were the most prominent local symptoms of the metastatic tumors.

Wheeze and dyspnea are worthy of special comment. The importance of wheeze as a symptom of onset in primary bronchial growth has been pointed out by Clerf (3). Its importance is not generally recognized. In this series it was recorded as being present in only six (or 12 per cent) of the patients, but in the histories of the remaining 44 (or 88 per cent) of the group, it was not mentioned as being present or absent, indicating that it was not sought for routinely. If in every instance the patient had been questioned as to wheeze, the incidence would undoubtedly be much higher, because with extension of the growth after its onset wheeze is masked, cough and expectoration, because of the distress they cause the patient, becoming the prominent features.

Dyspnea was the most frequent complaint of the 35 of the 78 patients with metastasis who had pulmonary symptoms. It occurred in 23 (or 65.7 per cent) of the cases. This is in contrast to its incidence in the primary group in which it occupied the fourth place, cough, expectoration, and pain all being recorded more frequently. The higher incidence in metastasis is probably due to the massive pleural effusions secondary to pleural metastasis which so often accompany pulmonary metastases.

Duration and Prognosis (Table III).—The ultimate fate of all patients with primary bronchial tumors is not known, and comparison as to the duration of life with that of the metastatic group cannot be made. However, the interval between the onset of the first symptom and the first medical examination in the

primary group, and the interval between discovery of the primary tumor and death in the metastatic group, are known and furnish a basis for comparison.

Tumors which metastasize to the lungs are more rapidly fatal than are primary bronchial growths. The finding of pulmonary metastasis is a grave prognostic sign.

TABLE III.—COMPARISON OF PRIMARY AND METASTATIC PULMONARY MALIGNANCY DURATION

Primary (50 Cases) (Time Interval from Onset to First Medical Examination)			Metastatic (78 Cases) (Time Interval from Discovery of Primary Tumor to Death)	
	No.	Percentage	No.	Percentage
1–6 months	14	28	35	44.8
6–12 months	9	18	16	20.5
1–2 years	15	30	10	12.8
2 years and more	8	16	7	8.9
Indeterminate	4	8	10	12.8

Of the patients with pulmonary metastasis, 55 (or 65.3 per cent) died in less than a year from the time of discovery of the primary tumor. It should be borne in mind that duration of life is reckoned from the finding of the causative tumor and not from the time of recognition of the metastasis. In contrast with this, it could be determined that 23 (or 46 per cent) of the patients with primary bronchial tumors had endured the initial symptom for more than a year before they first sought medical advice as to the cause of the symptom. In many instances it took again as long before the diagnosis of the etiologic factor was finally made by histologic examination of tissue removed at bronchoscopy.

Roentgen Characteristics (Table IV).—In the primary tumors indications of collapse of a lobe or a portion of a lobe was the most frequently encountered roentgenologic sign. It occurred in 20 (or 40 per cent) of the cases. Then followed increased linear markings in 14 (or 28 per cent) mass in 12 (or 24 per cent), abscess in three (or 6 per cent), and pleural effusion in one (or two per cent). The diagnosis of primary bronchial carcinoma can rarely be made by roentgen examination alone, though when atelectasis is found in adults with respiratory symptoms of protean character the examiner should be strongly suspicious of bronchial neoplasm and advise the bronchoscopic removal of a piece of tissue for histologic examination.

TABLE IV.—COMPARISON OF PRIMARY AND METASTATIC PULMONARY MALIGNANCY ROENTGENOLOGIC CHARACTERISTICS

Primary		Metastatic
Atelectasis		
Increased linear markings		
Mass-tumor	Nodule	Number Outline Density Distribution Size
Abscess		
Pleural effusion		

The shadow of the nodule is pathognomonic of metastasis. Nodules rarely occur in the lungs in other conditions. The shadows of the nodules present the same characteristics that the nodules do on gross morbid examination. They are usually round, sharply circumscribed shad ows of which there may be either only a few or an innumerable number. They range in size from a few millimeters to several centimeters, and may occur in a limited portion of one lung or be scattered throughout both lungs from apices to bases. They range in density from faint nebulous shadows to densely opaque masses. Complications alter the roentgenologic appearance of both the primary and metastatic growths. In the primary growth necrosis of the center, with abscess formation, is frequent. In metastasis there is a high incidence of pleural effusion which, in many instances, hides the characteristic metastatic nodules.

CONCLUSIONS

Comparison of 50 cases of histologically proven bronchial carcinomas with 78 cases of metastatic pulmonary malignancy proven by necropsy indicate that:

1. Primary pulmonary malignancy has a greater incidence in males than metastatic malignancy. In the primary cases 90 per cent were males and 10 per cent

females; in the metastatic group 68 per cent occurred in males and 32 per cent in females.

2. Both primary and metastatic malignancy occur most frequently between 40 and 60 years of age; but before 20 years and after 70 years the incidence of metastatic malignancy is greater than that of primary.

3. In primary malignancy respiratory symptoms were much more marked than in metastasis; in 98 per cent of the patients with primary carcinoma there were respiratory symptoms, whereas, in the metastatic only 45 per cent had local manifestations.

4. Wheeze is a frequently overlooked important initial symptom of primary bronchial neoplasm.

5. The discovery of pulmonary metastasis is graver than the discovery of primary bronchial malignancy, 65 per cent of the patients with pulmonary metastasis died within a year of the finding of the causative tumor, while 46 per cent of those with primary bronchial carcinoma endured the initial symptom for a year before they sought medical advice.

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DISCUSSION

DR. JOHN D. CAMP (Rochester, Minn.): After Dr. Clerf's comprehensive paper, Dr. Rigler's discussion, and Dr. Farrell's paper which Dr. Clerf has kindly read, there is little left to be said concerning this subject.

There are a few points, however, in the text of Dr. Farrell's paper which might bear comment.

In the first sentence Dr. Farrell refers to the increasing occurrences of primary bronchial carcinoma. Personally, I am not convinced that bronchial carcinoma is increasing in incidence. I still think, although somebody might like to argue this with me, that the apparent increasing incidence is due rather to our increasing diagnostic accuracy, improvement in clinical methods, and familiarity with the symptoms.

Dr. Clerf mentioned the significance of the occurrence of a wheeze in bronchial carcinoma and its absence in metastatic lesions. He has referred to this, I believe, in the past and perhaps this sign has not been appreciated as much as it should be. I think that if we all interrogated these patients more carefully, we might find this sign very helpful in the differential diagnosis.

There is one significant point which these figures bring out. (I am sorry that Dr. Farrell didn't break down these figures, because I am sure they would be of interest to those who like cancer statistics.) That is, that 65 per cent of the patients with pulmonary metastases died in less than one year from the time of discovery of the primary tumor. It would be interesting to know what types of malignancy these were. Perhaps Dr. Clerf can help us on that point. However, if 65 per cent of patients die within a year of the recognition of the initial lesion, there is a lot to be thought of here in regard to improving our therapy.

In regard to roentgen characteristics, the matter of atelectasis has been commented upon and the difficulty of recognizing any characteristic roentgenographic sign of primary malignancy has been brought out. Here, I think, is well shown the necessity for close co-operation between the radiologist and the clinician in appraising the significance of many of the shadows which we see in the roentgenogram.

Dr. Farrell mentioned the significance of the nodule in the diagnosis of metastatic lesions. That is true, particularly, when they are multiple. However, when we have a single nodular lesion, which is not common but which is not truly rare, the distinction between a benign neoplasm, an inflammatory lesion, and a primary parenchymal malignancy may be exceedingly

difficult because some of these nodular primary malignancies may be peripherally located and not accessible to bronchoscopic examination.

When a primary malignant nodular lesion undergoes cavitation, we may have considerable difficulty in differentiating it from an inflammatory lesion with cavitation. Personally, I think the thickness of the wall of a cavity may help one a little, and in my experience primary malignancy with cavitation has been associated with thicker and more irregular walls than inflammatory lesions, with cavitation.

One last point I would like to emphasize —that is the necessity of making films of the thoracic spine in all cases of tumor masses in the posterior mediastinum. We know that a neurofibroma may be primary within the chest but a fair percentage of intraspinal neurofibromas (25 per cent of our last series) may protrude through an intervertebral foramen into the posterior mediastinum. The chest film may suggest a solitary intrathoracic mass. However, enlargement of an intervertebral foramen and erosion of the contiguous vertebral pedicle indicate the intraspinal origin of the tumor. In these conditions it is helpful to know that the lesion is both intraspinal and intrathoracic because the surgical approach must be adapted accordingly.

DR. CLERF (closing): Answering Dr. Camp's inquiry concerning the tumors of the metastatic group, I can say only that a large number were sarcomas and that about 28 per cent of all the metastatic tumors originated from tumors of the urogenital organs.

Concerning the question of an actual increase in the incidence of bronchial tumors it seems that there are more cases now than formerly, irrespective of improved diagnostic methods. Probably one factor is the increased expectancy of life.

Wheezing respiration often is overlooked both by the patient and the physician. Many patients are not aware that they are wheezing until their attention is directed to it by the family or friends. Recently a patient with partial bronchial obstruction produced by cancer, and with wheezing respiration, was admitted to the Bronchoscopic Clinic for study. I asked him if he had ever noticed a wheezing sound when he breathed and he replied in the negative. Had he been admitted after bronchial obstruction became complete the wheeze would have been absent. The patient very probably would have replied in the negative to any inquiry concerning wheezing.

Theoretically, every patient with partial bronchial obstruction should wheeze at some time.

ROENTGENOGRAPHIC UNSHARPNESS OF THE SHADOW OF A MOVING OBJECT[1]

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INTRODUCTION

THE shadows of the heart and of the parenchyma of the lungs are unsharp, or blurred in chest roentgenograms. The greatest part of this unsharpness is commonly attributed to three phenomena:

1. Roentgen rays emanate from a finite area, the roentgen-ray tube focal spot (geometric unsharpness).
2. The roentgenographed objects move during the roentgen-ray exposure (unsharpness due to motion).
3. Roentgen-ray films and intensifying screens produce unsharpness due to the characteristics of the materials of which they are made.

Roentgenographic unsharpness has been studied by Bouwers (1), Bronkhorst (2), Chantraine (3), Zuppinger (4), and others.

Bouwers has expressed the geometric unsharpness and the unsharpness due to motion in terms of the exposure time for a given roentgenographic technic. He has then shown that the arithmetic sum of these two unsharpnesses may be minimized uniquely by the usual process of differentiation. The results may be stated in this form: There is one and only one exposure time which will produce minimum "total unsharpness"[2] for a given roentgenographic exposure energy, tube rating, and velocity of the roentgenographed object. His work is summarized in the form of curves for particular practical conditions. Bouwers notes that the optimum exposure times which he calculates depend upon the characteristics of the roentgen-ray films and intensifying screens which are used. As the speeds of these auxiliary materials are increased by improved manufacturing methods, the exposure times for minimum "total unsharpness" decrease.

Bouwers shows in one of his papers (1) that if the unsharpness due to intensifying screens may be added arithmetically to "total unsharpness," then there are definite criteria, which depend upon the unsharpness due to intensifying screens and the intensification factor, to determine whether or not screens should be used. He concludes that under the present conditions so long as the velocities of motion of the parts to be roentgenographed are of the order of a few millimeters per second, and so long as the intensifying screens are of the type generally available at the present time, then the use of screens results in the production of smaller unsharpness than the use of technics without screens.

Certain results which are derived below from the geometric aspects of the roentgenographic problem lead to the conclusion that the unsharpness due to motion and the geometric unsharpness are not arithmetically additive. It may be shown in fact that a shadow for which geometric unsharpness is X millimeters *appears* to have the same unsharpness as a shadow which has a "total unsharpness" of $2X$ millimeters, of which X millimeters represents geometric unsharpness and X millimeters represents unsharpness due to

[1] The Moore School X-ray Laboratory has been organized at the University of Pennsylvania under grants by the National Tuberculosis Association. The material contained in this paper has been submitted to the Moore School of Electrical Engineering as part of the requirements which are prerequisite to the awarding of the degree of Doctor of Science in Electrical Engineering.

[2] Throughout this paper the "total unsharpness" (with the quotation marks for emphasis) represents the arithmetic sum of the unsharpness due to motion and the geometric unsharpness.

motion. It is the purpose of this paper to present in broad outline methods by which the geometric unsharpness and the unsharpness due to motion may be combined to obtain a measure of the observed unsharpness.[3]

The unsharpness due to intensifying screens has also been studied by Chantraine (3) and others. It has been concluded that the unsharpness due to intensifying screens is of the order of 0.1 millimeter to 0.3 millimeter. The results of this investigation show that if the unsharpness due to intensifying screens is of the order of 0.1 millimeter to 0.3 millimeter, as measured by Chantraine, then this unsharpness may be an important contribution to observed unsharpness in roentgenograms made with intensifying screens. Therefore, although the effects of the unsharpnesses produced by intensifying screens and x-ray films are not considered in this paper, it should be recognized that the study of these effects is necessary for the complete analysis of unsharpness of clinical roentgenograms. These effects will be studied by methods like those described in this paper and the results combined with the results which are presented below. It should be emphasized, therefore, that precise clinical applications of the results obtained in this paper require further investigation of associated problems.[4]

The unsharpness due to x-ray film has been shown to be smaller in practice than any of the contributions to unsharpness described above. The effect of unsharpness due to x-ray film is, therefore, neglected throughout this paper.

[3] Throughout this paper the observed unsharpness represents the observed width in millimeters of the shadow of an object which moves parallel to the x-ray film during exposure, after the film has been processed and is examined by means of a film illuminator. The observed unsharpness in this paper refers to shadow borders obtained without the use of intensifying screens or with the use of intensifying screens if the unsharpness due to the screens may be neglected.

[4] Also note on page 464 that clinical application depends upon further study of the motion of roentgenographed objects, as, for example, the motion of the heart and the parenchyma of the lung.

The investigation of roentgenographic unsharpness which is described herein comprises:

I. The calculation of the roentgenographic unsharpness without intensifying screens of the shadow of a plane object moving with constant velocity parallel to the plane of the roentgen-ray film.
II. The description of experiments performed in order to test the results of the calculations of I.
III. The deduction of tentative criteria for minimum observed unsharpness in chest roentgenograms. These criteria are tentative since further data are required for their precise calculation.
IV. Problems which must be solved in order that the results of I and II may be used to obtain precise criteria for minimum observed unsharpness in clinical roentgenograms.

I. THE CALCULATION OF ROENTGENOGRAPHIC UNSHARPNESS

An x-ray tube is mounted at a distance $(a + b)$ centimeters from an x-ray film. A plane of x-ray absorbing material is mounted at a distance b centimeters from the x-ray film and this object may be moved parallel to the x-ray film with constant velocity. The planes of the object and film are parallel. Figure 1 represents these devices in diagrammatic form: The x-ray tube focal spot f, the object o, and the film F. The heavy lines in Figure 1 are the traces on the plane of the paper of the effective focal spot, the object, and the film. The remaining lines are geometric constructions to be discussed below.[5]

It should be noted that the distances a, b, f, etc., are not drawn to scale in

[5] In actual practice the trace of the focal spot would not, of course, be perpendicular to the line $t_o x_o$. However, the length f having been defined as the length of one side of the effective focal spot of a line focus tube, the resultant calculations will be accurate to a high degree of approximation and the calculations are greatly simplified by this procedure.

Figure 1. Actually in roentgenographic work the distances are on the average of the orders of magnitude given below:

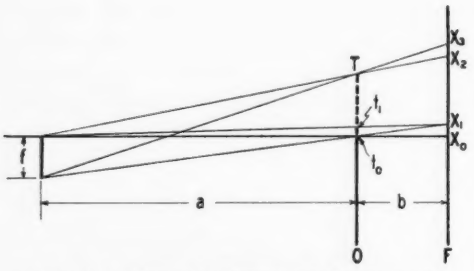


Fig. 1. Schematic diagram *not drawn to scale* of the trace f of the effective focal spot of a roentgen-ray tube, the trace O of a plane object which moves with constant velocity v cm. per second in the direction t_oT, and the trace F of a plane x-ray film. A perspective view of the experimental apparatus is shown in Figure 5.

(1) The length a is of the order of $10b$; (2) the side of the square effective focal spot f is of the order of $0.003a$; (3) the distance travelled by the object edge during the roentgen-ray exposure is always less than $0.01a$, and in clinical routine it is usually of the order of $0.002a$.

During roentgen-ray exposure the phenomena are assumed to proceed as follows: At the instant t_o the edge of the object o intersects the line x_ot_o (Fig. 1). The object moves with constant velocity v centimeters per second from t_o to T. At the time t_o a roentgen-ray exposure of constant intensity begins. This exposure continues until time T when the object edge has arrived at the point T. The focal spot f then stops emitting roentgen rays. The object edge therefore travels vT centimeters during the constant intensity roentgen-ray exposure.

If all distances are measured in centimeters, the following geometric relations may be derived from Figure 1 and the description of the experiment described above:

$$x_1 = \frac{bf}{a} \qquad x_2 = \frac{a+b}{a}vT$$

$$vt_1 = \frac{bf}{a+b} \qquad x_3 - x_2 = x_1 = \frac{bf}{a}$$

During exposure the roentgen-ray intensity at points on the film above x_3 is I; the characteristics of the object are supposed to be such that during the exposure the intensity at points below x_o is I_o; the total exposures above x_3 and below x_o are, therefore, IT and I_oT, respectively. Using the symbol E for total exposure, these facts may be summarized:

$$E_x = IT \qquad (x \geqslant x_3)$$

$$E_x = I_oT \qquad (x \leqslant x_o)$$

The following method is used to calculate the exposure E_x for points lying between x_o and x_3; *i.e.*, within the band of border unsharpness. Note that in most earlier papers on this subject $x_1 = \frac{bf}{a}$ is called the "geometric unsharpness"; $x_2 = \frac{a+b}{a}vT$ is called the "unsharpness due to motion," and $x_3 = x_1 + x_2$ is called the "total unsharpness."

Consider first the region from $x_o = 0$ to $x_1 = \frac{bf}{a}$. Designate distances measured in this region from $x_o = 0$ by the symbol α. At $\alpha = 0$ the intensity at $t_o = 0$ is I_o and is constant during the exposure. Therefore, as described above:

$$E_{\alpha=o} = I_oT$$

At $\alpha = x_1$ the intensity at time $t = 0$ is I. The intensity at this point decreases linearly with the time to I_o at time $t_1 = \frac{bf}{v(a+b)}$. The intensity is constant and equal to I_o from time t_1 to time T. This is shown graphically in Figure 2 in which the roentgen-ray intensity upon the film at x_1 is i_{x_1} at any time t.

The total exposure E_{x_1} is:

$$E_{x1} = \int_o^T i_{x1}\,dt = \frac{bf}{2v(a+b)}(I - I_o) + I_oT$$

For any α between $\alpha = 0$ and $\alpha = x_1$, the initial intensity (at $t = 0$) is a fraction of I given by

$$i_{o\alpha} = \frac{a}{bf}\alpha I + \left(1 - \frac{a}{bf}\right)I_o$$

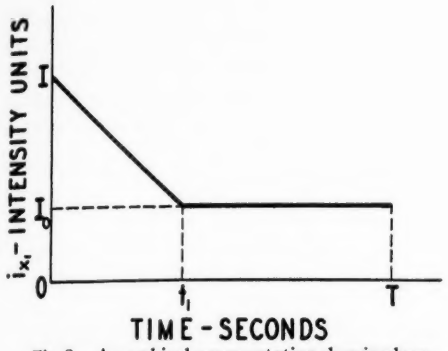


Fig. 2. A graphical representation showing how the roentgen-ray intensity i_{x_1} along a strip of film perpendicular to the plane of the paper at x_1, Figure 1, varies with time during an exposure of T seconds.

The intensity decreases from this initial value to I_o at time t_α. From t_α to T the intensity is I_o. The time t_α when the object intercepts the radiation (except I_o) is:

$$t_\alpha = \frac{a\alpha}{v(a+b)}.$$

During the exposure the intensity at α, therefore, varies as shown in Figure 3.

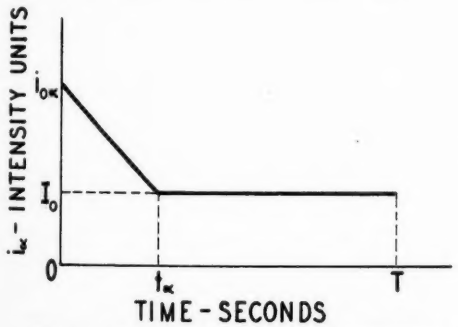


Fig. 3. A graphical representation showing how the roentgen-ray intensity i_α along a strip of film perpendicular to the plane of the paper (Fig. 1) between x_0 and x_1 distant α cm. from x_0 varies with time during an exposure of T seconds.

From the relations given above and from Figure 3, the total exposure at α (where α is measured from x_o) may be calculated:

$$E_\alpha = \int_o^T i_\alpha dt = \frac{1}{2} t_\alpha (i_{o\alpha} - I_o) + I_o T$$

$$E_\alpha = \frac{1}{2} \frac{a^2(I - I_o)}{bfv(a+b)} \alpha^2 + I_o T \quad (0 \leqslant \alpha \leqslant \frac{bf}{a})$$

By this method the total exposures E_β and E_δ, for points between x_1 and x_2, and between x_2 and x_3, respectively, may be calculated from

$$E_\beta = \frac{a}{v(a+b)} (I - I_o)\beta + \frac{bf}{2v(a+b)}(I - I_o) + I_o T \quad (0 \leqslant \beta \leqslant x_2 - x_1)$$

$$E_\delta = \frac{-a^2}{2bfv(a+b)}(I - I_o)\delta^2 + \frac{a}{v(a+b)} (I - I_o)\delta - \frac{bf}{2v(a+b)} (I - I_o) + IT \quad (0 \leqslant \delta \leqslant x_3 - x_2)$$

in which β is measured from x_1 and δ is measured from x_2.

Figure 4 shows graphically the variation of E with x for three cases for which the sum $(x_1 + x_2)$ is the same. In Figure 4-*A* the curve is calculated for $x_1 = x_2$. In this case the first half of the curve is E_α, the second half is E_δ. The formula for E_β is not used, because $x_2 - x_1 = 0$, *i.e.*, β does not exist. Figure 4-*B* shows the calculation for x_2 twice as large as x_1. In this case α, β, and δ have equal ranges, *i.e.*, from zero to $\frac{bf}{a}$.

There remains the case where x_2 is very small compared to x_1. Although this may be calculated in the same manner that E_α, E_β, and E_δ are deduced above, it is simpler to obtain the result in another manner. If x_2 is very small with respect to x_1 the result is similar to that which would be obtained if v were put equal to zero; *i.e.*, if the object were stationary. The curve E *vs.* x for this case is

$$\overline{E}_x = \frac{a}{bf} (I - I_o)Tx + I_o T \quad (0 \leqslant x \leqslant x_1)$$

This is shown in Figure 4-*C*.

These curves suggest that the shadow border of Figure 4-*A* would appear considerably sharper than the borders represented by either Figure 4-*B* or Figure 4-*C*, even though the same value of x_3, the "total unsharpness," is obtained in all cases. Experiments to test this suggestion are described in the next section.

Certain psycho-physiologic factors must be considered when these results are applied to clinical roentgenography. Bronkhorst (2) shows that the unsharpness which

is perceived in a roentgenogram depends not only upon the density of the film throughout the unsharp area, but also upon the contrast between the two areas on either side of the unsharp area. He shows that this perceived unsharpness is in general less than the unsharpness measured by methods like the one described below. There appears to be a dark line parallel to the unsharp border shadow in the more dense area and a bright line parallel to it in the less dense area. Bronkhorst shows figures in which he has sketched dotted lines to represent observed unsharpness. This point must be thoroughly investigated not only for shadows like those described in this section, but also for unsharp shadow borders having widths equal to those encountered in roentgenographic practice, *i.e.*, 1.5 millimeters or less.

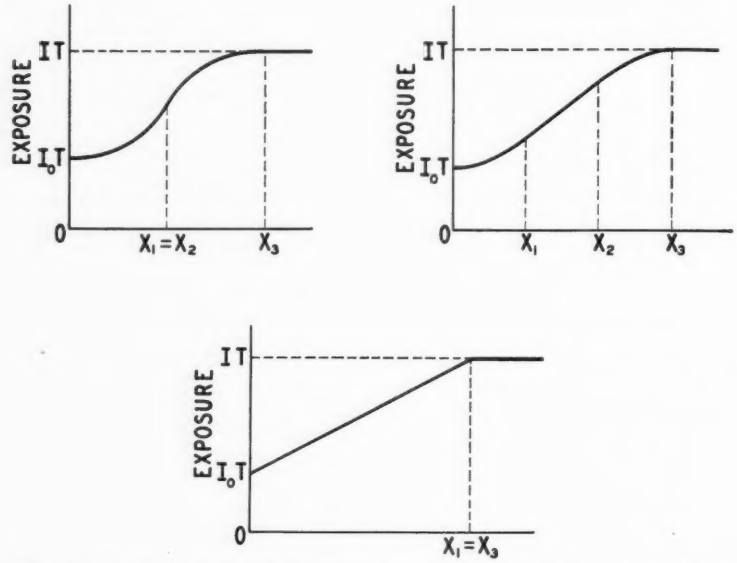


Fig. 4. The theoretical variation of roentgen-ray exposure with x measured from x_0 upward (Fig. 1) for three cases:

Fig. 4-*a*, upper left, $x_1 = x_2$ or $\frac{x_2}{x_1} = 1$

Fig. 4-*b*, upper right: $x_2 = 2x_1$ or $\frac{x_2}{x_1} = 2$

Fig. 4-*c*, lower: $x_2 = 0$ or $\frac{x_2}{x_1} = 0$

The sum $(x_1 + x_2)$ is the same in all three cases.

II. EXPERIMENTAL PROCEDURE

The experimental procedure for testing the theoretical conclusions of Section I consists essentially of an assembly of apparatus like that represented diagrammatically in Figure 1. The apparatus actually used is shown in Figure 5 and described in the caption of that figure. The effective focal spot of the x-ray tube is approximately square, the sides 5 millimeters in length. Double coated roentgen-ray film was used for the experiments. Pieces of this film were wrapped in black paper and enclosed in a special bakelite cassette. The front cover of the cassette was made of one-sixteenth inch bakelite. Films were continuously but irregularly agitated during development in commercial elon-hydroquinone developing solution. The apparatus used for these experiments

consisted of a four-valve roentgenographic equipment with a capacity of 100 kv.p., 400 ma. X-ray exposures were chosen so that the apparatus operated in a stable, easily controlled manner. The velocities of motion, the distances a and b, were chosen arbitrarily for convenience so that the calculated x_1 and x_2 were of the order of magnitude necessary for accurate density measurements as described below. This experimental set-up, therefore, does not exactly simulate conditions obtained in roentgenographic practice. The experimental conditions were chosen for convenience.

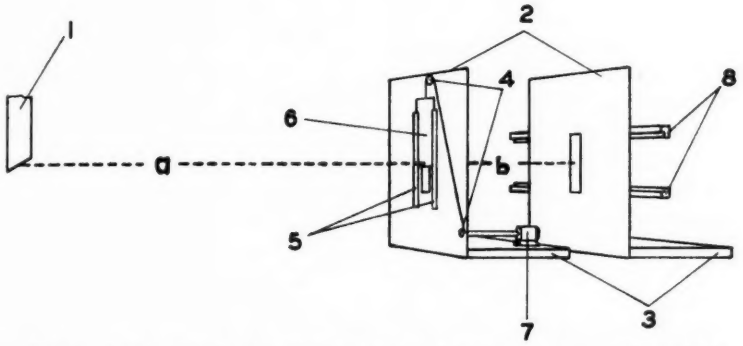


Fig. 5. Perspective drawing of apparatus used in the experiments described in Section II. *1*, anode of roentgen-ray tube; *2*, lead sheets each having a rectangular aperture at its center; *3*, wood base mountings for lead sheets *2*; *4*, pulleys, the lower of which is rotated by means of a synchronous motor *7*; *5*, brass guides for *6*; a sheet of lead which is moved upward over the aperture in lead sheet *2* by means of a silk thread fastened at the top of *6* which runs over the upper pulley *4* and is fastened to the periphery of the lower pulley *4*; *7*, a synchronous clock motor which drives the lower pulley *4* (attached to its shaft) at a constant angular velocity of one revolution per minute.

In order to make accurate measurements of density the "total unsharpness" must be of the order of one centimeter. It is, of course, true that the unsharpness obtained in usual roentgenographic procedures seldom exceeds one millimeter and is very often less than 0.5 millimeter. However, the conclusions derived from these tests have been further applied to the study of unsharpness of the order of two millimeters. It was shown by these tests that the observed unsharpness is the same for all values of "total unsharpness" from two millimeters to one centimeter. Nevertheless, after further investigations are made of the problems described in the introduction to this paper, it will be necessary to show that the conclusions derived from the work given below are applicable in practical cases.

In order to use an x-ray beam of approximately the same character as that which is incident upon the film in general roentgenography a filter of 3 one-eighth inch discs of aluminum was placed over the aperture in the x-ray tube from which the radiation emanates.

The choice of the exposure time is prescribed by the fact that if the object moves with a very high velocity the pulsations in x-ray intensity due to the x-ray tube voltage wave form will produce striations in the unsharp shadow border. Exposure times and velocities are chosen, therefore, so that these striations are so narrow that they may be neglected. The exposure time for all test films was three seconds.

The experimental procedure may be best illustrated by describing a particular test. It was desired to obtain a roentgenogram for which $x_1 = 0.44$ centimeter and $x_2 = 0.44$ centimeter. It was desired to obtain densities of approximately 0.2 and 1.0 on either side of the unsharp border. It will be noted that it is convenient to choose a

fixed focal spot-film distance for all tests, *i.e.*, to make $(a + b)$ constant. In all of the tests the focal spot-film distance was 80 centimeters. Having fixed $(a + b)$ it is necessary to choose a, b, and v so that $\frac{bf}{a}$ is equal to 0.44 and $\frac{a+b}{a} vT = 0.44$. This results in the use of $a = 43$ centimeters, $b = 37$ centimeters, and $v = 0.075$ centimeter per second. In order to produce the desired densities it was found that the x-ray exposure should be as follows: x-ray tube voltage 54 kv.p., product of x-ray tube current and exposure time 90 milliampere-seconds.

The edge of the lead sheet was approximately three centimeters below the center line of the x-ray beam when the motor was started. As the edge of the lead sheet approached the center line the x-ray exposure was begun. Before and after each test the velocity of motion of the object edge was measured by noting the time required for it to traverse a distance of two centimeters and then calculating the velocity in centimeters per second.

A number of exposures were made using the lead plate as a moving object. Of these the technics for three were chosen to produce shadows like those in Figure 4. The technics used for these three films are listed in Table I. It will be noted that the ratios of x_2 to x_1 for roentgenograms 1, 2, and 3 are 1, 2, and 0, respectively. These are precisely the forms shown in Figure 4.

TABLE I

For all films:	Roentgen-ray tube voltage = 54 kv.p. Roentgen-ray tube current = 30 ma. Exposure time = 3 seconds		
Film Number	1	2	3
a cm.	43	50	28.5
b cm.	37	30	51.5
v cm./sec.	0.075	0.125	0
$x_1 = \frac{bf}{a}$ cm.	0.43	0.30	0.90
$x_2 = \frac{a+b}{a} vT$ cm.	0.425	0.60	0
$\frac{x_2}{x_1}$	1	2	0

A number of films were made using an aluminum plate in place of the lead plate as moving object. By varying the x-ray tube voltage and the x-ray tube current it is possible to produce any degree of contrast between the two areas of the roentgenogram that may be desired, within the limits normally encountered in roentgenography. Tests of this nature must necessarily be expanded if the methods described in this paper are to be applied to general problems. However, since insufficient data are now available for treating this general problem no attempt is made in this paper to discuss results of the tests using an aluminum plate. It will suffice to note that nothing appears from these preliminary tests to suggest that the conclusions derived from the tests with the lead plate are not generally applicable.

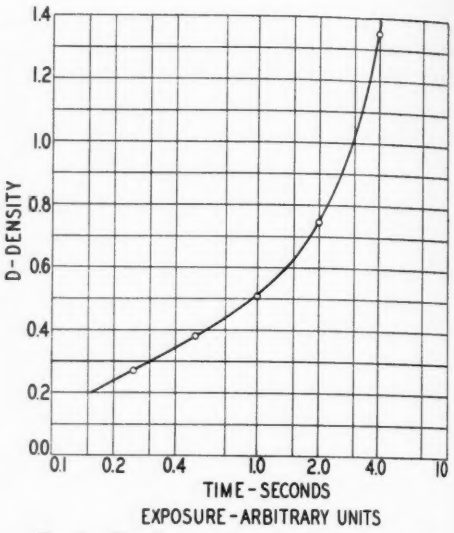


Fig. 6. Density *vs.* exposure characteristic of the particular film used in these tests.

After the films were processed the variation of density along the film parallel to the direction of motion of the object was measured by means of a microdensitometer.[6] The microdensitometer uses two photoelectric cells. Light from a tungsten

[6] The author acknowledges the privilege extended to him by Dr. W. F. G. Swann, Director of Bartol Research Foundation of the Franklin Institute, to use the microdensitometer in the Bartol Laboratory, and also the aid of Mr. Lipman, Dr. Swann's associate, for his instruction in the use of the instrument.

filament lamp is split into two beams, one of which impinges upon one of the photoelectric cells. This photoelectric cell is so connected that small changes in light intensity do not affect the readings of the instrument. The second beam is focused upon an area of the film to be measured. This area is approximately one millimeter by one-tenth millimeter, the short dimension lying in the direction x of the test roentgenogram. The light transmitted through the film is reflected into the second photoelectric cell. An electrometer with an illuminated scale reads the difference between the photoelectric cell currents so that its deflection is proportional to the opacity of the film. The sensitivity of the device may be adjusted so that it is possible to cover the entire range of densities of the roentgenograms 1, 2, and 3 described in Table I with one setting of the microdensitometer. The deflection of the electrometer is proportional to the intensity of the light transmitted by the film. The deflection of this instrument was plotted in terms of film density by using a standard neutral gray density tablet. In this manner the instrument was used as a comparative microdensitometer.

Each of the films 1, 2, and 3, described in Table I, was placed[7] upon the movable table of the microdensitometer in such a manner that it could be moved in the direction x by means of a calibrated control on the densitometer. Density readings were then obtained along the axis of x in steps of 0.5 millimeter. The data for these three test films have been plotted with crosses in Figure 7.

In order to compare these experimental results with those derived theoretically in Section I it is necessary to obtain values for I and I_o and a curve showing relations between the exposure E and the density D. The characteristics of the film were obtained by exposing five areas of a piece of film in the apparatus successively at a distance of 80 centimeters from the roentgen-ray tube with different exposure times.

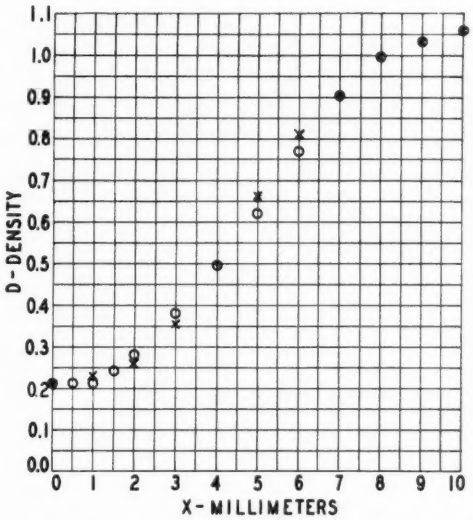


Fig. 7. Calculated (o) and experimentally determined (x) variations of roentgenographic densities D with x (Fig. 1) for three cases:

Fig. 7-*A*: $x_1 = x_2$ or $\frac{x_2}{x_1} = 1$

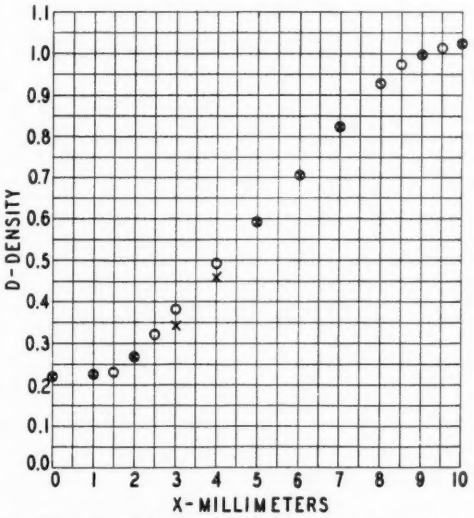


Fig. 7. Calculated (o) and experimentally determined (x) variations of roentgenographic densities D with x (Fig. 1) for three cases:

Fig. 7-*B*: $x_2 = 2x_1$ or $\frac{x_2}{x_1} = 2$

[7] Note that in the experimental procedure (see Fig. 5) the object moves in the sense opposite to that in Figure 1. Films made in these two ways are physically indistinguishable if x_o and the direction $x_o x_3$ are properly chosen.

The film was developed in the same manner as test films. The density of each area was measured by means of the microdensitometer. A curve was constructed of exposure time *vs.* roentgenographic density.

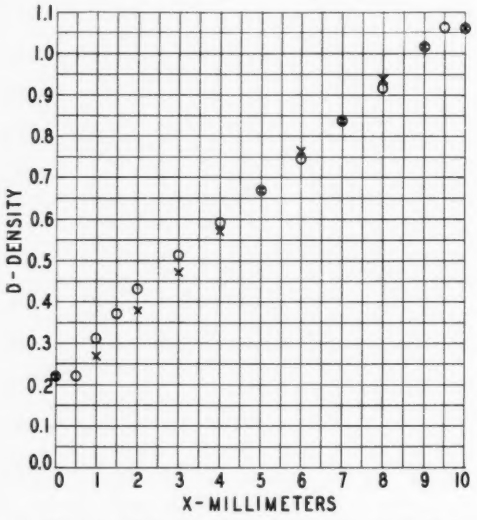


Fig. 7. Calculated (o) and experimentally determined (x) variations of roentgenographic densities D with x (Fig. 1) for three cases:

Fig. 7-*C*: $x_2 = 0$ or $\frac{x_2}{x_1} = 0$

This curve is shown in Figure 6. Although the exposure time was varied in the tests used to obtain this characteristic curve the abscissas may be unambiguously called exposure units. Since all of the work herein described is concerned with this particular sample of x-ray film, it is unnecessary to attempt to find the exposure in absolute units.

The following calculation describes the method used for obtaining theoretically the variation of roentgenographic density with x, the distance along the unsharp shadow border. This calculation is given completely below for roentgenogram No. 2, for which the data are given in Table I. It is first necessary to measure the maximum density and the minimum density of roentgenogram No. 2. These are, respectively, 1.02 and 0.22. From the curve in Figure 6 it may be seen that in arbitrary units

$E_{max} = 3.00 = IT$ or $I = 1.00$ $\qquad$ $E_{min} = 0.176 = I_oT$ or $I_o = 0.059$

since $T = 3$ seconds.

The exposure data for roentgenogram No. 2 are:

$a = 50$ cm.
$b = 30$ cm.
$v = 0.125$ cm./sec.
$x_1 = \frac{bf}{a} = 0.3$ cm.
$x_2 = \frac{a+b}{a} vT = 0.6$ cm.
$x_3 - x_2 = x_1 = 0.3$ cm.
$T = 3$ seconds
$f = 0.5$ cm.

The formula for the total exposure E_α from $x = 0$ to $x = \frac{bf}{a}$ has been obtained from Section I:

$$E_\alpha = \frac{1}{2} \frac{a^2(I - I_o)}{bfv(a+b)} \alpha^2 + I_oT$$

Substituting the values of I and I_o obtained above, this formula for E_α reduces to

$$E_\alpha = 7.84\ \alpha^2 + 0.176$$

The values of E_α are calculated for $\alpha = 0$, 0.05, 0.10 . . . 0.30 cm. For each value of E_α so calculated the density D_α is read from the curve, Figure 6. In Table II the values of α E_α, and D_α are listed.

TABLE II

α cm.	E_α Arbitrary Units	D_α
0	0.176	0.22
0.05	0.196	0.23
0.10	0.254	0.28
0.15	0.352	0.32
0.20	0.490	0.38
0.25	0.666	0.43
0.30	0.882	0.48

A similar procedure is used to calculate densities for points between x_1 and x_2 by means of the equation for E_β which is:

$$E_\beta = \frac{a}{v(a+b)} (I - I_o)\beta + \frac{bf}{2v(a+b)} (I - I_o) + I_oT \qquad (0 \leq \beta \leq (x_2 - x_1))$$

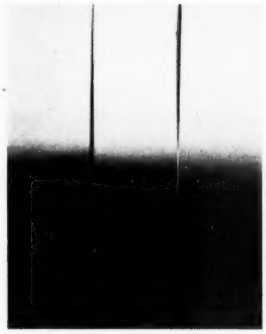
and for points between x_2 and x_3 by means of the equation for E_δ which is:

$$E_\delta = -\frac{a^2}{2bfv(a+b)} (I - I_o)\delta^2 + \frac{a}{v(a+b)} (I - I_o)\delta - \frac{bf}{2v(a+b)} (I - I_o) + IT \qquad (0 \leq \delta \leq (x_3 - x_2)).$$

Values of I and I_o, obtained above, are substituted in the formulas for E_β and E_δ. From these calculated exposures the densities are read from Figure 6.

Data calculated in this manner for test films 1, 2, and 3 are plotted (o) in Figure 7. Data obtained experimentally by measuring the test films with the microdensitometer are plotted (x) in the same figure.

It will be noted that the variations between the experimentally determined density values and those obtained by means of the theory outlined in Section I and the characteristics of the film are within the probable limits of experimental error. This close agreement indicates that the calculations in Section I constitute a consistent theory of the facts obtained experimentally. It will be noted that the curves in Figure 4, as well as those in Figure 7, represent results obtained with different values of x_1 and x_2 but with the further qualification that $(x_1 + x_2)$ is constant for all three films. It is clear that the unsharpness which would be observed if these three films were held before an illuminator would be different in spite of the fact that $(x_1 + x_2)$, the "total unsharpness," is the same for all films. The next section is devoted to a discussion of the observed differences in these three films.



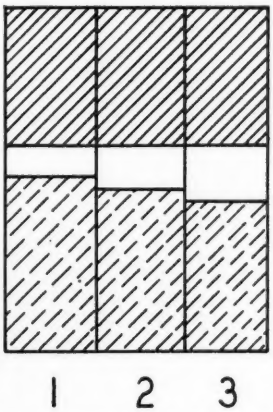


Fig. 8 (*left*). Contact prints of roentgenograms 1, 2, 3, the technics for which are listed in Table I. *Left*, roentgenogram No. 1: "total unsharpness," 0.86 cm.; $\frac{x_2}{x_1} = 1$; approximate observed unsharpness, 0.44 cm. *Center*, roentgenogram No. 2: "total unsharpness," 0.90 cm.; $\frac{x_2}{x_1} = 2$; approximate observed unsharpness, 0.67 cm. *Right*, roentgenogram No. 3: "total unsharpness," 0.90 cm.; $\frac{x_2}{x_1} = 0$; approximate observed unsharpness, 0.90 cm.

Fig. 8 (*right*). Line drawing showing widths of shadows measured by observers. Broken line cross-hatching represents the areas of the original films of density 0.2; solid line cross-hatching represents the areas having a density of 1.0; the small areas without cross-hatching represent areas of observed unsharpness.

Figure 8 is a reproduction of positive prints of test films 1, 2, and 3 for which the technics are described in Table I. The original films were arranged so that the points $x = 0.9$ cm. were in line. Contact prints were then made and these prints reproduced in Figure 8. The darker portions of the prints correspond, of course, to less dense portions of the original films.

A number of observers who examined these films were of the opinion that the

horizontal lines shown in the diagram to the right of the reproduction of the prints represented the borders of the observed unsharpness of the original films. Thus, although the "total unsharpness" is the same for all three films, the observed unsharpness in roentgenogram No. 1 is approximately one-half of the unsharpness in roentgenogram No. 3, while the unsharpness in roentgenogram No. 2 is approximately three-fourths of the observed unsharpness of roentgenogram No. 3.

This shows that the observed unsharpness does not depend solely upon the "total unsharpness" but may differ for a given value of $(x_1 + x_2)$, depending upon the ratio of x_2 to x_1.

III. THE DEDUCTION OF TENTATIVE CRITERIA FOR MINIMUM OBSERVED UNSHARPNESS IN CHEST ROENTGENOGRAMS

It has been shown above that the observed unsharpness depends not only upon the "total unsharpness" $(x_1 + x_2)$ but also upon the ratio of x_2 to x_1. Specifically it has been shown that the observed unsharpnesses in three roentgenograms, for each of which $x_1 + x_2 = 0.9$ cm., are approximately in the proportion 2:3:4 for ratios of $\frac{x_2}{x_1}$ equal to 1, 2, 0, respectively.

The precise application of this result to the problems of chest roentgenography requires the accurate solution of a number of problems discussed in the Introduction and in Section IV below. Nevertheless, the results described above may be combined with the data now available for two purposes: (1) To illustrate the methods of calculation for applying the results given above to chest roentgenographic technic, and (2) to obtain by means of such calculations tentative criteria for chest roentgenographic technics which will produce minimum observed unsharpness.

This Section (III), therefore, comprises sample calculations combining the results of Section I and II with the practical factors of chest roentgenographic technic. The results given in this Section in the forms of curves and tabulated data are suggested as tentative criteria for chest roentgenography. The confirmation or modification of these results depends upon the solution of problems outlined in the Introduction and discussed further in Section IV below.

Bouwers (1) has shown how the factors defined above as $x_1 = \frac{bf}{a}$ and $x_2 = \frac{a + b}{a} vT$ may be reduced to a function of the exposure time T, and the sum minimized, thus specifying technics for minimum "total unsharpness" $(x_1 + x_2)$. He has pointed out that the improvement of roentgen-ray films and intensifying screens makes necessary the recalculation of these criteria. The focal spot size f depends upon the electric energy required to make the roentgenogram, and this energy, in turn, is decreased by improvements in films and screens.

At the present time high quality chest roentgenograms may be made with roentgen-ray tube voltages not exceeding 78 kv.p. and milliampere-seconds and total energies depending upon the focal spot-film distance, as follows:

Focal Spot-film Distance		Milliampere-seconds	Energy at 78 kv.p. Watt-seconds
Meters	Feet		
1.25	4	8.3	470
1.50	5	12.2	670
1.83	6	18.2	1000

It is further assumed that the *actual* focal spot of a 19° stationary anode line focus roentgen-ray tube may be safely loaded up to 250 watts per square millimeter, and that a rotating anode roentgen-ray tube may be safely loaded up to 1,500 watts per square millimeter. These ratings are in accord with modern practice, if the exposure time does not exceed 0.15 second.

Postero-anterior roentgen kymography of the profile of the heart has shown velocities parallel to the film up to one centimeter per second in normal patients under normal conditions and higher velocities in patients whose hearts are abnormal

or who are excited or who have just exercised violently. It seems probable that during the diastolic phase of the cardiac cycle these velocities are generally less than 0.5 cm. per second. Several writers, in order to calculate roentgenographic unsharpness, have assumed an average velocity for the heart, and for the vessels near the heart, of 0.5 cm. per second. In the calculations which follow data are given for $v = 0.5$ cm. per second and for $v = 0.25$ cm. per second; the higher figure is judged to be a mean, subject to wide variations, for roentgenograms made at random cardiac phase; the lower value is assumed to hold for roentgenograms taken in the diastolic phase of the cardiac cycle.

As noted in Section II, the test roentgenograms 1, 2, 3 were made so that the ratios $\frac{x_2}{x_1}$ were 1, 2, 0, respectively. The observed unsharpnesses for these films were judged to be in the ratio 2:3:4, respectively. If this triple ratio is expressed in terms of $(x_2 + x_1)$, which was constant for all three films, it is $^1/_2$:$^3/_4$:1. Note also that in chest roentgenography the ratio $\frac{x_2}{x_1}$ lies between limits $0.05 \leqslant \frac{x_2}{x_1} \leqslant 2.5$ for all technics used in practice.

It is concluded, therefore, that the observed unsharpness U_o may be expressed

$$U_o = \Phi\left(\frac{x_2}{x_1}\right)(x_2 + x_1)$$

where $\Phi\left(\frac{x_2}{x_1}\right)$ is a function of $\frac{x_2}{x_1}$, so chosen that the results obtained in Section II are satisfied. The function $\Phi\left(\frac{x_2}{x_1}\right)$ must, therefore, be chosen so that

$$U_o\Big]_{\frac{x_2}{x_1}=0} = 1 \quad (x_2 + x_1) \qquad \text{(test film No. 3)}$$

$$U_o\Big]_{\frac{x_2}{x_1}=1} = \frac{1}{2} \quad (x_2 + x_1) \qquad \text{(test film No. 1)}$$

$$U_o\Big]_{\frac{x_2}{x_1}=2} = \frac{3}{4} \quad (x_2 + x_1) \qquad \text{(test film No. 2).}$$

The function $\Phi\left(\frac{x_2}{x_1}\right)$, for which three values have been obtained, could be expressed accurately as a power series in $\frac{x_2}{x_1}$. However, aside from the complication of calculations with such a function, there is no need for such accuracy as long as the velocities of roentgenographed parts are known only approximately. In view of these facts the function $\Phi\left(\frac{x_2}{x_1}\right)$ is defined as follows:

$$\Phi\left(\frac{x_2}{x_1}\right) \equiv 1 - \frac{1}{2}\,\frac{x_2}{x_1} \qquad 0 \leqslant \frac{x_2}{x_1} \leqslant 1$$

$$\Phi\left(\frac{x_2}{x_1}\right) \equiv \frac{1}{4}\left(1 + \frac{x_2}{x_1}\right) \qquad 1 \leqslant \frac{x_2}{x_1} \leqslant 3.$$

Note that this definition is based upon the values of observed unsharpness for test films Nos. 1, 2, and 3, so that $\Phi(1) = \frac{1}{2}$, $\Phi(2) = \frac{3}{4}$, $\Phi(0) = 1$.

The observed unsharpness U_o is, therefore:

$$U_o = \left(1 - \frac{1}{2}\,\frac{x_2}{x_1}\right)(x_2 + x_1) \qquad 0 \leqslant \frac{x_2}{x_1} \leqslant 1$$

$$U_o = \frac{1}{4}\left(1 + \frac{x_2}{x_1}\right)(x_2 + x_1) \qquad 1 \leqslant \frac{x_2}{x_1} \leqslant 3.$$

It is, therefore, possible to calculate the observed unsharpness in a roentgenogram of an object b cm. from an x-ray film which is $a + b$ cm. from a tube having an effective focal spot f cm. square if this object moves parallel to the film with a constant velocity v cm. per second throughout an x-ray exposure of constant intensity of duration T seconds. Examples of such calculations follow. As noted in the beginning of this Section and discussed in Section IV, the results of these calculations may be tentatively applied to chest roentgenographic technic, subject to modification when the factors of this technic may be determined more precisely.

The calculations which follow lead to the graphical representation of the observed unsharpness, as a function of exposure time, of the border of an object moving parallel

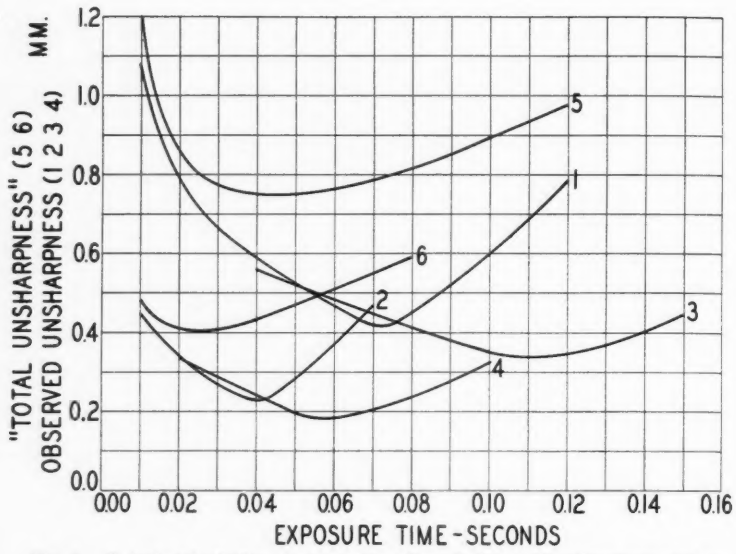


Fig. 9. Calculated relations between "total" and observed unsharpness, and exposure time:

Curve No.	Unsharpness	Velocity of Object (v) cm. per sec.	Type of Roentgen-ray Tube
1	Observed (U_0)	0.5	stationary anode
2	Observed (U_0)	0.5	rotating anode
3	Observed (U_0)	0.25	stationary anode
4	Observed (U_0)	0.25	rotating anode
5	"Total" ($x_1 + x_2$)	0.5	stationary anode
6	"Total" ($x_1 + x_2$)	0.5	rotating anode

to the x-ray film with a velocity 0.5 cm. per second *neglecting the unsharpness due to films and intensifying screens.* The focal spot-film distance is 1.5 meters (approximately 5 feet), the required exposure is 670 watt seconds,[8] the object is 15 cm. from the film and the x-ray tube is of the 19° line focus type. The required data are:

a = 135 cm. Actual focal spot area—$3f^2$ *cm*^{2}.
b = 15 cm. Energy for exposure—670 watt-seconds
v = 0.5 cm./sec. Load capacity of tube—250 watts/mm.^{2} or 25,000 watts/-cm.^{2}

$$x_2 = \frac{a+b}{a} vT = 0.556T \text{ cm.}$$

$$3f^2 = \frac{670}{25{,}000\ T}; \quad f = 0.0945T^{-1/2} \text{ cm.}$$

$$x_1 = \frac{bf}{a} = 0.0105\ T^{-1/2} \text{ cm.}$$

$$\frac{x_2}{x_1} = 53T^{3/2}; \qquad \frac{x_2}{x_1} = 1 \text{ if } T = 0.071 \text{ sec.}$$

Substituting these values in the equations given in the last paragraph:

$$U_o = 0.28T + 0.0105T^{-1/2} - 14.8T^{5/2} \qquad (0.01 \leqslant T \leqslant 0.07)$$

$$U_o = 0.28T + 0.0026T^{-1/2} + 7.4T^{5/2} \qquad (0.07 \leqslant T \leqslant 0.12)$$

The results are shown in Curve 1, Figure 9. In a similar manner Curves 2, 3, 4, Figure 9, were calculated for v = 0.5 cm./sec. with a rotating anode tube, v = 0.25 cm./sec. with stationary anode tube, and v = 0.25 cm./sec. with a rotating anode tube, respectively. Curves 5 and 6 show the "total unsharpness" ($x_2 + x_1$) as a function of exposure time T.

Note that, as might be expected from the nature of the problems, each curve of Figure 9 specifies the unsharpness at any focal spot-film distance from 1.25 meter to 1.83 meters. Although there are different formulas for f for each focal spot-film distance, the values of x_1 and x_2 as functions of T are approximately the same for all distances within this range.

If the factors assumed for these calculations are correct for chest roentgenography,

[8] See page 460.

and if it is desired to use one x-ray tube for all adult chests, technics may be calculated for minimum observed unsharpness at focal spot-film distances from 1.25 meters (4 feet) to 1.83 meters (6 feet). These technics are listed in Table III.

TABLE III.—TECHNICS FOR MINIMUM OBSERVED UNSHARPNESS FOR OBJECT 15 CM. FROM THE ROENTGEN-RAY FILM MOVING WITH CONSTANT VELOCITY v IN A DIRECTION PARALLEL TO THE FILM

			Focal Spot-film Distance		
			1.25 m. 4 feet	1.5 m. 5 feet	1.83 m. 6 feet
v = 0.5 cm./second	Stationary anode tube (observed unsharpness 0.41 mm.)	Effective focal spot side (mm.)	3.0	3.6	4.4
		Roentgen-ray tube voltage (kv.p.)	50–78	50–78	50–78
		Roentgen-ray tube current (ma.)	120	174	260
		Exposure time (seconds)	0.07	0.07	0.07
	Rotating anode tube (observed unsharpness 0.23 mm.)	Effective focal spot side (mm.)	1.6	1.9	2.4
		Roentgen-ray tube voltage (kv.p.)	50–78	50–78	50–78
		Roentgen-ray tube current (ma.)	208	305	455
		Exposure time (seconds)	0.04	0.04	0.04
v = 0.25 cm./second	Stationary anode tube (observed unsharpness 0.34 mm.)	Effective focal spot side (mm.)	2.4	2.8	3.5
		Roentgen-ray tube voltage (kv.p.)	50–78	50–78	50–78
		Roentgen-ray tube current (ma.)	76	111	166
		Exposure time (seconds)	0.11	0.11	0.11
	Rotating anode tube (observed unsharpness 0.19 mm.)	Effective focal spot side (mm.)	1.3	1.6	1.9
		Roentgen-ray tube voltage (kv.p.)	50–78	50–78	50–78
		Roentgen-ray tube current (ma.)	139	203	303
		Exposure time (seconds)	0.06	0.06	0.06

IV. OTHER FACTORS WHICH INFLUENCE THE OBSERVED UNSHARPNESS IN CHEST ROENTGENOGRAMS

It is the purpose of this Section to derive certain conclusions from the work described above and to point out certain factors in chest roentgenographic technic which are not included in the analysis in those Sections.

Figure 9 shows that equal observed unsharpnesses (0.43 mm.) are produced with an exposure time of 0.067 second for a stationary anode tube and for a rotating anode tube. The sides of the effective focal spots are 3.6 mm. for the stationary anode tube and 1.4 mm. for the rotating anode tube. This result may appear anomalous, since if a chest roentgenogram is made with a stationary anode tube having an effective focal spot 3.6 mm. square, and a second film is made with a rotating anode tube having an effective focal spot 1.4 mm. square *with the other technical factors unchanged*, experience suggests that the shadow borders in the second film are sharper than those in the first. It is quite true that the shadows of the posterior ribs and of the parts of the lung which more slowly during exposure will be more sharp in the second film. However, the profile of the heart and the shadows of vessels near the heart will have the same unsharpness in both films, if they move parallel to the film with a velocity of 0.5 cm. per second as it was assumed when the data for the Curves 1 and 2, Figure 9, were calculated. This point is discussed further below.

Note that the slopes of Curves 1 and 2, Figure 9, change more rapidly near the points of minimum unsharpness than the slopes of Curves 3 and 4 at corresponding points. This leads to the conclusion that, if it is necessary or desirable to deviate from the exposure times of minimum unsharpness, there is a smaller loss of sharpness for objects moving slowly than for those moving faster. Therefore, if a large part of the object roentgenographed moves

relatively slowly, the exposure time may be increased and the focal spot size decreased *without obtaining gross unsharpness in the faster moving parts if these parts move with velocities of 0.25 cm. per second or less.* If, as suggested below, most of the parts within the thorax move relatively little, then the greatest overall or "average" sharpness will be attained by making all exposures in the diastolic phase of the cardiac cycle, *i.e.*, during the interval when the parts having the highest velocities are moving most slowly.

The general conclusions concerning the relation of observed unsharpness to "total unsharpness" were further tested by the following experiment: Note that in roentgenogram No. 1, (Table I) $x_1 = 0.43$ cm., $x_2 = 0.425$ cm., $U_0 = 0.43$ cm. According to the conclusions reached in Section III, if an exposure were made at exactly the same technic but with the object stationary, there would result $x_1 = 0.43$ cm., $x_2 = 0$ cm., $U_0 = 0.43$ cm. Two films were made in this manner and are reproduced in Figure 10. Although they differ in appearance (*i.e.*, density is a different function of x in the two cases), a number of observers held that the widths of the shadow borders were equal.

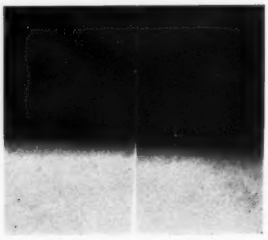


Fig. 10. *Left:* $x_1 = 0.43$ cm., $x_2 = 0$ cm., $U_0 = 0.43$ cm.
Fig. 10. *Right:* $x_1 = 0.43$ cm., $x_2 = 0.425$ cm., $U_0 = 0.43$ cm.

Two further questions arise concerning the applicability of these results to chest roentgenography:

1. Is the function $\Phi\left(\frac{x_2}{x_1}\right)$ dependent upon the magnitude of the "total unsharpness"?
2. Does the function $\Phi\left(\frac{x_2}{x_1}\right)$ depend upon the contrast between the two areas of the film between which the unsharpness is produced?

The function $\Phi\left(\frac{x_2}{x_1}\right)$ was chosen upon the basis of roentgenograms having a contrast of 0.8 and for which $x_1 + x_2 = 0.9$ cm. The experiments were repeated with contrasts[9] of 0.1 and 0.2, and also with a "total unsharpness" of 0.2 cm. In all cases observers concluded that the results described above were valid. However, if the data required for a precise study of chest roentgenography are obtained, these tests should be repeated with a view to extending the results to "total unsharpnesses" less than 0.1 cm. Such tests require a refinement of the experimental method described above, but no fundamental modification thereof.

As noted in the Introduction, the unsharpnesses due to intensifying screens and to x-ray film require further study. Plans for such studies have been formulated. It is hoped, incidentally, that an objective measure of intensifying screen unsharpness may be obtained as a by-product of this work.

Before more definite criteria for minimum unsharpness in chest roentgenograms may be obtained it is necessary to study in more detail the motion of parts within the thorax. This may be done with the aid of a kymograph and a device for making roentgenographic exposures at any predetermined phase of the cardiac cycle.

If these physical measurements are made, it will be possible to record shadows of parts within the thorax in such a manner that the unsharpnesses may be accurately calculated. Under these conditions the roentgenologist could study films made in a variety of ways to determine just what shadows must be sharp if the diagnostic value of the film is to be as high as possible.

[9] The average film densities were 1.00.

It might be concluded from the material above that exposure times greater than those given in Table III and focal spots smaller than those listed in this Table would produce films most useful in view of present knowledge. However, until this knowledge is extended the optimum technics cannot be precisely determined. For example, there may be cases in which the sharp delineation of shadows near the base of the heart is of extreme importance. In this particular case a knowledge of the velocities of the parts in this region, and a device for making exposures in a predetermined cardiac phase would make possible the minimization of unsharpness *in this region*. Throughout the remainder of the chest shadow the unsharpness would probably be excessive, so that a second film, taken at a different technic might be required.

SUMMARY

1. Theoretical derivations and experimental results show that the observed unsharpness of an object moving with constant velocity parallel to a roentgen-ray film (without intensifying screens) differs, in general, from the arithmetic sum of the unsharpness due to object motion and the unsharpness due to the finite focal spot size.

2. Methods are described for calculating the observed unsharpness of the roentgenographic shadow of an object moving with constant velocity parallel to the film as a function of exposure time.

3. The observed unsharpness is calculated for a plane object distant 15 cm. from the roentgen-ray film with velocities of 0.5 cm. per second and 0.25 cm. per second, using both stationary anode tube and rotating anode tube of modern design.

4. These calculations show that for focal spot-film distances between 1.25 meter and 1.83 meters (4 feet to 6 feet), the unsharpness of the shadow border of the object is minimum for exposure times as follows:

Tube	Object Velocity (cm. per sec.)	Exposure Time for Minimum Unsharpness (second)	Observed Unsharpness (Without Intensifying Screens) (mm.)
Stationary anode	0.5	0.07	0.41
Rotating anode	0.5	0.04	0.23
Stationary anode	0.25	0.11	0.34
Rotating anode	0.25	0.06	0.19

for the exposure energies required for chest roentgenography.

5. The unknown factors which prevent the precise calculation of the criteria for minimum observed unsharpness in chest roentgenograms are discussed. Methods for studying some of those factors are outlined.

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THE CONGENITAL HEART[1]

A RADIOLOGIC STUDY, WITH SEVEN REPORTED CASES

By J. FRIEDMAN, M.D., *New York City*

SEVEN cases of congenital heart disease (five newborn infants and two children of eight and one-half and fourteen years, respectively), clinically and roentgenologically observed, are reported, with three necropsies. This group comprises

4 cases of Fallot's tetralogy, one of them with right-sided aortic arch and one with complete transposition of the great vessels;
1 case of Eisenmenger's tetralogy, with coarctation;
1 case of complete dextrocardia;
1 case of partial dextrocardia.

Congenital heart disease is rare and its diagnosis difficult. Autopsies have disproved many apparently quite certain clinical and roentgenologic diagnoses. Some of these anomalies show pathognomonic roentgenologic signs, as coarctation of the aorta and right-sided aortic arch; others have a normal roentgen appearance, while in still others, the roentgenologic signs are capable of various interpretations. An example of the latter is the dilated pulmonary arch, held by Vaquez to be typical of a persistent ductus Botalli and by Assmann as significant of pure pulmonary stenosis. These anomalies are nearly always multiple, complicating still more the diagnostic difficulties.

Fig. 1-*A*.

Fig. 1-*B*.

In the newborn the heart is globular, its left half rounded off, the left border showing only two arches, namely, the aorta and the ventricle. As to its size, it is often extremely difficult to decide whether or not

[1] From the Roentgen Department of the Women's General Hospital, Montreal. The writer wishes to thank Dr. W. H. Chase and Dr. H. Segall for their valuable contributions.

there is enlargement. An associated thymus hyperplasia will vary the cardiac size and form.

CASE REPORTS

Case 1. B. A., 14-year-old boy, was referred by Dr. D. Raff on Nov. 8, 1934. He appeared well developed and in good health. The cardiac size and sounds were normal, no murmur being present. The cardiac impulse was felt in the right sixth intercostal space. The electrocardiogram was characteristic of dextrocardia. The teleroentgenogram (Figs. 1-*A* and 1-*B*) showed dextrocardia. The measurements were: Right margin, 9 cm.; left margin, 4 cm.; longitudinal diameter, 14.5 cm.; chest transverse, 28 cm. The right diaphragmatic dome was slightly lower than the left, and below it the gastric air bubble and the gas-filled splenic flexure were visualized. The barium meal confirmed the complete situs inversus viscerum.

Case 2. Baby V. B., female, was born Jan. 4, 1933, a spontaneously delivered, full-term child. At birth, the left nipple was seen to be absent, and there was indrawing of the left anterior chest wall on deep inspiration.

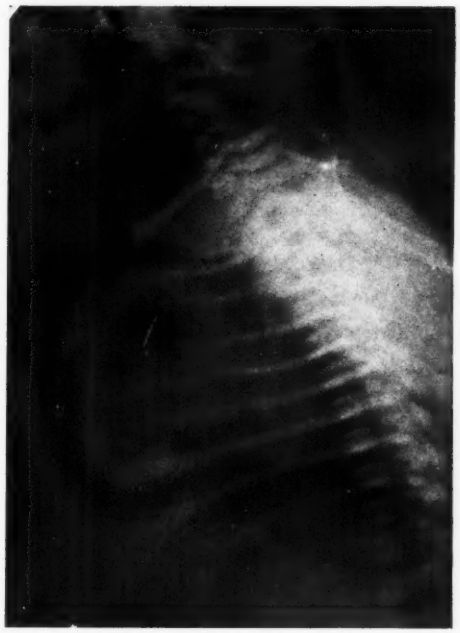

Fig. 2-*A*.

Roentgen examination on January 6 (Fig. 2-*A*) showed an aplasia of the anterior osseous portions of the left first, second,

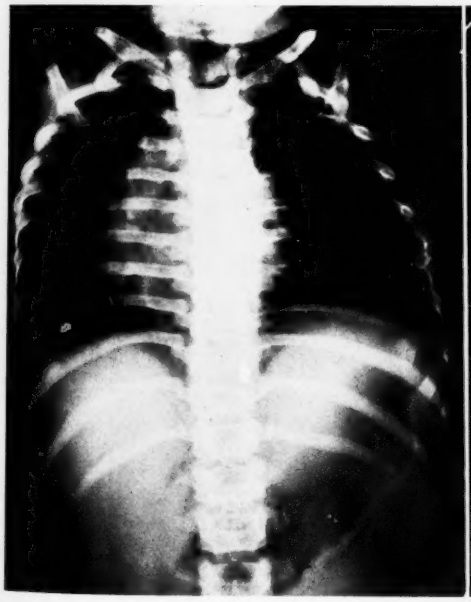

Fig. 2-*B*.

Fig. 2-*C*.

Fig. 3.

third, fourth, and fifth ribs. A dextrocardia without transposition of the viscera was found. The heart was globular, the sounds normal, there was no murmur. The electrocardiographic report, January 20, was as follows: "The degree of right axis deviation is within normal limits for an infant of this age, in whom the right ventricle is larger than the left under normal conditions."

The child was seen two years later, in perfect health. Roentgen examination (Figs. 2-*B* and 2-*C*), made on Nov. 6, 1934, showed dextrocardia and, more clearly, the costal defects.

Case 3. Baby H., male, born Nov. 20, 1932, of a healthy mother, by spontaneous, normal delivery. He seemed perfectly well until the fifteenth day of life, when he developed a series of attacks of cyanosis and died two days later. The x-ray examination on December 5 (Fig. 3) showed a globular heart enlarged to the right and left. The necropsy findings were: transverse precordium, 7 cm.; thymus (rather small), 9 gm.; large defect in the intraventricular septum; hypertrophic dilatation of the right and left ventricles; dextroposition of the aorta, the valve over-riding the septal defect. There was coarctation of the aorta near the isthmus. The pulmonary artery was dilated, thin-walled, and well preserved. Patent foramen ovale and a large patent ductus arteriosus. The conclusion was that this was a case of the tetralogy of Eisenmenger, with coarctation.

Fig. 4-*A*.

Fig. 4-*B*.

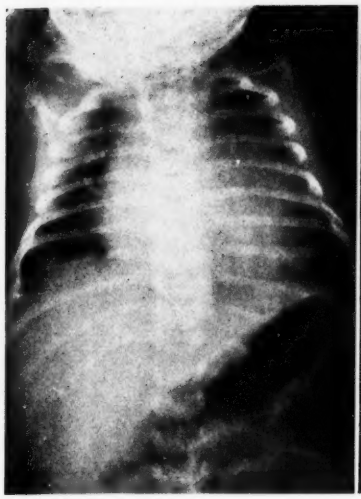

Fig. 5-*A*.

Fig. 5-*B*.

Case 4. Baby R., female, born Jan. 7, 1932, a full-term infant delivered by cesarean section. Cyanosis became definite shortly after birth and was controlled only by continuous administration of oxygen. A rough systolic murmur was heard all over the precordium, being loudest in the aortic area. An electrocardiographic report on January 10 was as follows: "Normal axis; low voltage in all leads, and inverted T waves point to toxic myocardiac condition, in this case probably due to anorexia." Roentgen examination on January 10 showed a large globular heart and a widened supracardiac shadow. Clinically and roentgenologically the case was considered a thymus hyperplasia rather than a congenital heart. Radium was applied. The baby died on the fourth day of life. The autopsy findings were as follows: transverse precordium, 7 cm. (right margin, 3 cm., left margin, 4 cm.). There was a rather large thymus, extending to 2 cm. above the base of the precordial space, 3 cm. wide at the base of the pericardium, but not extending beyond its lateral border. The weight of the thymus gland was 20 grams. The very large right ventricle lay transversely. There was marked hypertrophy and dilatation of both right and left ventricles. The large aorta rose entirely from the right ventricle. There was partial atresia of the pulmonary orifice, with a very narrow conus; the first part of the pulmonary artery showed marked dilation. A small defect existed at the base of the intraventricular septum under the pulmonary valve. Both the ductus arteriosus and the foramen ovale were widely patent. The conclusion was that the case was one of the tetralogy of Fallot, with transposition of the great vessels.

Case 5. Baby R., female, was born March 17, 1933, by spontaneous delivery. Hematuria was noticed for the first week after birth, and on March 24 there was cough, followed by choking spells and cyanosis. Similar paroxysmal cyanotic attacks recurred in the next few months. The physical signs were negative, no murmur being heard. Roentgen-ray examination on April 8 showed a large globular heart and enlarged thymus, with tracheal displacement and compression. Radium was twice applied, without result. The electrocardiographic report, on June 5, was as follows: "Marked right axis deviation signifying right ventricular preponderance. This points to pulmonic obstruction which is most likely complete (atresia)

Fig. 6-*A*.

since no murmur of stenosis exists." On September 7 a late, short, rough systolic murmur was heard at the apex. The child died at the age of seven months. The impression gained from the history, clinical and roentgenologic findings, and the electrocardiographic report was that the case was one of the tetralogy of Fallot.

Case 6. F. A., a boy eight and one-half years of age, was referred on Nov. 7, 1934, by Dr. W. Burnett. The patient was born at full term, with forceps delivery. The first cyanotic attack was noticed at seven months, after which similar attacks recurred frequently during the ensuing years. At the time of examination cyanosis and clubbed fingers were very marked. Hemoglobin was 152 per cent; erythrocytes per cubic millimeter, 10,000,000. A loud, rough systolic murmur accompanied the second half of the first sound and ran up to the second sound, a murmur that was heard all over the precordium except at the apex. Its maximum was at the pulmonic area, with a faint systolic thrill. The second sound was loud and sharp, loudest at the pulmonic area, and about equally loud in the aortic area. The first sound was reduplicated at the apex. The electrocardiogram showed a marked right axis deviation, typical of right ventricular preponderance as found in Fallot's tetralogy. The high voltage of P wave in lead II suggests enlargement of an auricle—in this case the right.

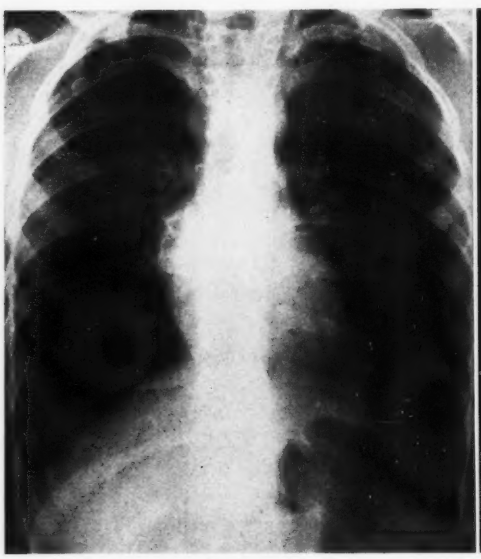

Fig. 6-*B*.

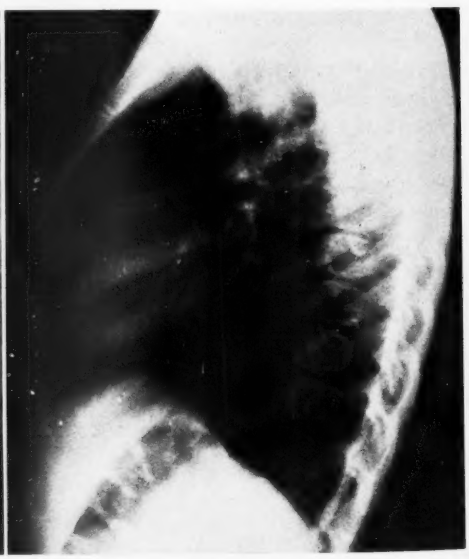

Fig. 6-*C*.

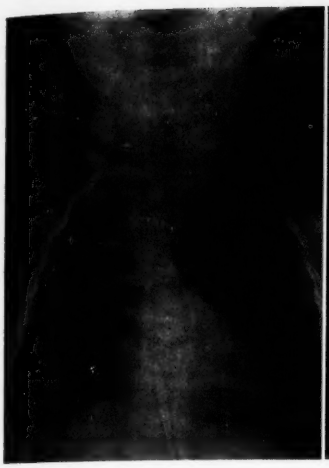

Fig. 7-*A*.

Fig. 7-*B*.

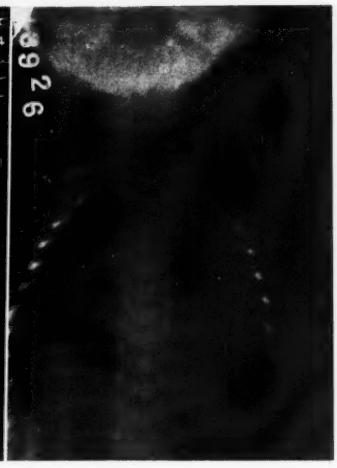

Fig. 7-*C*.

X-ray films were taken at six months and at eight and one-half years: Figure 6-*B* is a postero-anterior teleroentgenogram, Figure 6-*C* the lateral, and Figure 6-*D* the second oblique view. The heart is seen to be rather small in the vertical position. The right auricle is markedly prominent. The ascending aorta ascends 1 cm. to the right of the spine, while the aortic knob is visualized to the left of the spine. The pulmonary arc is retracted and the left hilum shows up clearly. The left ventricular arc is of increased convexity, the apex rounded off and slightly raised. The measurements are: right margin, 3 cm.; left margin, 4 cm.; longitudinal diameter, 8 cm.; chest transverse, 19 cm. The hila are moderately widened, increased linear markings extending toward the over-aerated lung bases. The diaphragmatic domes are straightened and much depressed during inspiration. The impression from the history, the clinical and roentgenologic findings, and the electrocardiogram is that the case is one of the tetralogy of Fallot.

Case 7. Baby M., male, born June 6, 1933, spontaneously at full term. The infant was cyanotic from birth: no murmur was heard and the sounds were normal. X-ray examinations were made July 10 and December 13. He fed well but continued to be blue. On December 16 the erythrocyte count was 10,000,000 per cubic millimeter. The cyanosis and respiratory embarrassment increased until death on December 17, at the age of five and a half months.

Figure 7-*A* shows marked enlargement of the heart shadow transversely with a rounded-off apex pushed to the left and upwards. The right auricle is very prominent. The pulmonary arch is markedly retracted, outlined medially with a sharp concave line, a clear space through which the left main bronchus shows up clearly. The ascending aorta is widened and the aortic arch seems to ride over the right bronchus. No aortic knob is visualized to the left of the spine.

Necropsy Findings.—Precordium, 5 cm.; right margin, 3 cm.; left margin, 2 cm. The thymus is small (8 mg.). The heart lies transversely, with markedly dilated right auricle and ventricle against the diaphragm; the apex is formed by the right ventricle, which is markedly hypertrophied. There is marked stenosis of the pulmonary artery, with an incompletely formed valve and much dilated conus. There is a large defect in the intraventricular septum at its base. The markedly dilated ascending aorta is deviated to the right, the aortic valves over-riding the septal defects. The

aortic extends 1 cm. to the right of the midline, crossing the right bronchus and descending along the right spinal border. Closed ductus arteriosus. There is a large patent foramen ovale, emphysema, and hypospadias.

Conclusion.—The case is diagnosed as showing the tetralogy of Fallot with high dextroposition of the aorta.

DISCUSSION

Cases 4 and 7 represent the radiological appearance of Fallot's tetralogy, with the heart in horizontal position, the very dilated right ventricle lying against the diaphragm and occupying nearly the entire cardiac surface. The apex is pushed to the left and raised and formed by the right ventricle. Case 6 represents the small vertical type of heart in Fallot's tetralogy with an hypertrophic right ventricle.

Assmann found the latter type in a case with small intraventricular septum defect and only slightly indicated right-sided aorta. The first type he found in several cases associated with a very large intraventricular septum defect and marked dextroposition of aorta. Our Case 4 showed a small septal defect with transposition of aorta, and Case 7 a large septal defect and right-sided aortic arch.

The degree of pulmonary stenosis, too, will probably influence the size of the right ventricle and so the cardiac form. In both our cases the stenosis of the pulmonary artery was marked. In Case 4 the presence of the large thymus complicates the interpretation of the cardiac form.

The radiologic appearance of Case 7 with the high dextroposition of the aorta was that of a sharply outlined, concave indentation of the left cardiac border and the *cœur-en-sabot* might be considered to be pathognomonic of Fallot's tetralogy.

The combination of the ventricular septum defect, right-sided aorta, and lack of stenosis of pulmonary artery has been named the Eisenmenger complex. Case 3, as the necropsy brought out, represents this type. The transversely enlarged globular heart should always be considered as suggestive of ventricular septum defect. The absence of right axis deviation in the electrocardiogram led correctly to exclusion of pulmonary stenosis.

Finally, the case of partial dextrocardia was found, as by other observers, to be associated with other deformities (in our case a very unusual rib defect).

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THE DETERMINATION OF THE NASO-FRONTAL SUTURE AND THE NASION IN THE LIVING

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IN the anthropometry of the living head perhaps the most important point is that at which the sagittal plane crosses the naso-frontal suture, a point known to anthropometrists as the *nasion*. The determination of this point in the living has always been a matter of considerable difficulty, and indeed, it is doubtful whether in the experience of the most competent investigator it has ever been accurately determined in more than a small percentage of cases. The methods which have been customarily used to determine the nasion in the living leave something to be desired,[1] and with the purpose of finding some fairly reliable method of securing this point, the writer undertook an investigation which led to the successful solution of the problem. The preliminary findings of this investigation, based upon the dissection of 240 human dissecting-room cadavera and the small number of ten x-ray studies of the living human head, were published in "The American Journal of Physical Anthropology" for April–June, 1935.[2] In the present communication the report upon two additional series of experiments is put before the readers of RADIOLOGY, together with the hitherto unpublished x-ray material, in the hope that it may be of some use to them in their work.

In my original paper I told how, as a consequence of preliminary dissections on 140 dissecting-room bodies in search of some possible relationship between the soft structures of the head in the orbito-nasal region and the naso-frontal suture, with particular reference to the nasion, I was led to the conclusion that a very close relationship existed between the level of the superiormost points of the superior palpebral sulci when the upper eyelids were elevated, as when the individual is looking straight ahead, and the level of the nasion (Fig. 1). In order to test the constancy, if any, of this suggested relationship the following experimental procedure was adopted: The recumbent head was placed in the Frankfurt Plane (a plane determined by the two inferiormost points on the inferior orbital margins and the auricular points immediately above the external acoustic rings), and by means of a metal tape, a horizontal tangential to the superiormost projection of the arches of the superior palpebral sulci was defined by gently placing the upper border of the tape against these arches. Where this horizontal intersected the mid-sagittal plane, a point determined by the eye alone, a hole was bored vertically through the soft tissues until it was felt that the gimlet used had slightly penetrated the bone. The instrument used in this operation was a 2-

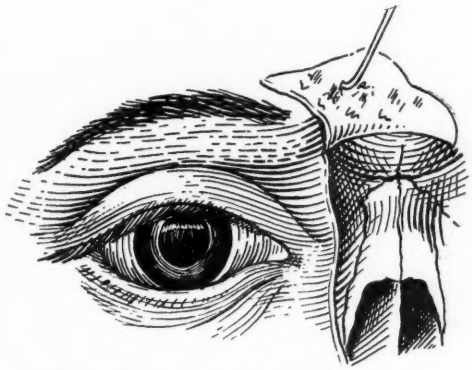

Fig. 1. Showing the relationship of the nasion to the level of the superior palpebral sulcus in a white adult male.

[1] For a critical examination of these methods see M. F. Ashley-Montagu, The Location of the Nasion in the Living, Am. Jour. Phys. Anthropology, 1935, **20**, 81–93.

[2] *Ibid.* This Journal, it should here be mentioned, contains a great deal of information which radiologists would, I am sure, find extremely valuable.

mm. bore hand-gimlet with a sharpened point. A deep incision passing through all the overlying tissues was then made from the glabella to a point midway down the front of the nose, and the whole region exposed; the periosteum was then with great difficulty dissected away from the bone, and the naso-frontal, the internasal suture, and the nasion exposed.

Fig. 2. Showing the relationships of the various structures in the naso-orbital region.

Out of 100 cases thus tested, the nasion was struck in all but three cases, and in these exceptional cases the gimlet hole was found to have penetrated the bone no more than a millimeter or so above the nasion. Such an astonishing series of successes really looked too good to be true, since not even the least informed morphologist would have expected to find so constant a relationship between a part of a structure formed entirely of soft tissues, namely, the most superior projections of the arches of the superior palpebral sulci, and a point formed by the association of purely osseous tissues determined by a plane. But there was no escaping the evidence of the experimental results which proved that the nasion was to be sought for on the same level as the superior points of the superior palpebral sulci when the individual had his eyes open and was looking straight ahead. The point at which the sagittal plane intersected a line extended between these points upon the face practically invariably corresponded to the position of the nasion.

In order to discover whether this relationship between the superior palpebral sulci and the nasion existed in the living, x-ray studies were made upon the heads of ten adolescent living white males. With one exception only, in which the film was a failure, the nasion, or at least the superior-most projection of the naso-frontal suture in the lateral view, was in each case accurately determined.

The method used in this x-ray study was as follows: The subject, standing upright, was asked to look straight ahead of him with his eyes normally open, so that the superior palpebral sulci were well defined; an ordinary piece of narrow-gauge fuse wire was then applied tangentially to the sulci and tied at the occiput. The subject was then placed horizontally upon his left side and a right lateral nasal exposure was made of the head and face. A lateral view of the region concerned was taken in preference to a frontal view because of the difficulty of interpreting an x-ray view of the naso-frontal suture. In a lateral view it is sometimes possible to see the naso-frontal suture quite clearly defined. When, however, this detail is for some reason obscured, the junction of the frontal and the nasal bones may generally be observed with little difficulty. In six of the ten cases x-rayed the naso-frontal suture was quite clearly visible, in three others the junction of the nasal with the frontal bones was alone visible, and in the tenth case such a junction was quite indistinguishable, the shadow of the frontal merging imperceptibly into that of the nasals.

In Figure 3 is seen a typical x-ray view of the head of a white male young adult, in which the apex of the wire may be seen appressed against the skin upon an exact horizontal with the level of the nasion. It will be observed in examining the figure that were a horizontal to be projected posteriorly toward the nasion from the apex of the wire it would strike the nasion precisely. These points are further clarified in the two drawings of another x-ray study seen in Figures 4 and 5. The relationship here demonstrated is precisely that which we endeavor to obtain in our attempts to locate the nasion in the living.

In order to check the accuracy of my procedure on cadavera I requested two of my colleagues to apply the method to some 15 undissected heads; this they were allowed to do alone and unaided. In every case they were able to strike the nasion exactly. To these gentlemen, Benjamin Freiband and Irving Wechselblatt, I am indebted for their assistance in this experiment.

Since the above observations were made I have had the opportunity to check the accuracy of this method of determining the nasion in two additional series of dissecting-room cadavera. In each series the bodies had been dead and embalmed for some three months, and it was not always easy to reproduce the superior palpebral sulci owing to the considerable loss of tone and shrinkage of the palpebrae. In my earlier series no body had been dead for more than six weeks and it was a matter of no great difficulty to produce the sulci by raising the superior palpebrae.

In the second series examined by myself the method followed was to place a wire tangential to the produced superiormost projection of the superior palpebral sulci while the head was lying on its occiput, and to bore a hole with a sharpened ice-pick at the point at which the sagittal plane intersected this horizontal. No attempt was made to put the head in the Frankfurt Plane, but care was taken to introduce the point of the ice-pick through the tissues at what was estimated to be a plane horizontal to the Frankfurt Plane. Out of the 37 cases thus investigated the nasion was determined exactly in 29 cases, and in the remaining eight cases the bore hole was found to be between 1 and 2 mm. from the nasion, in one case 2 mm. from the nasion on the frontal bone, in three cases 2 mm. from the nasion on the nasal bone, and in four cases 1 mm. from the nasion on the nasal bone. Allowing for the poorness of the material and the relative looseness of the method used these results were very gratifying.

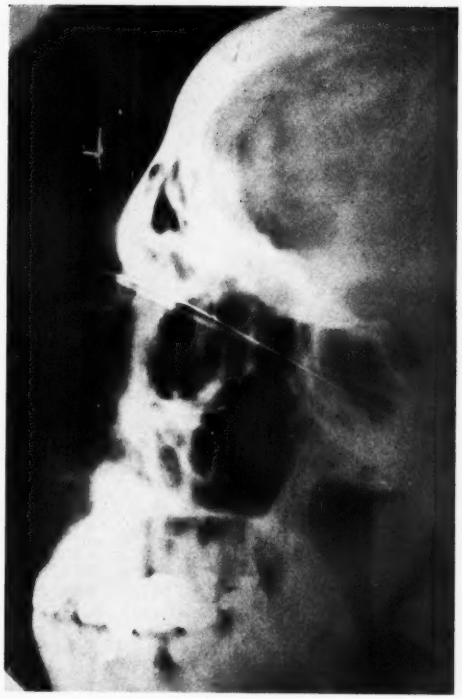

Fig. 3. X-ray view of the head of a young adult white male showing the apex of the wire appressed against the skin and situated upon an exact level with the nasion, the position of the *apex* of the wire corresponding to the level of the superior palpebral sulci.

It now remained to discover how foolproof the method was. For this purpose nine enthusiastic graduate students, who were completely untrained in the method here described, were given instructions to determine the position of the nasion by following the method I had used in making my second series of observations. Forty

Fig. 4. Drawing from an x-ray study of another young adult white male. The unbroken line represents the proximal portion of the wire; the broken line represents the distal portion of the wire on the other side of the head; at the orbit the wire is seen at the superior palpebral sulcus level which conditions the position of the wire at the front of the nose, where it is seen upon an exact level with the nasion. It should be quite clear that the position of the wire below the naso-frontal suture is not the position we are concerned with, but only with the position of the wire in front of the skin, a line between the latter and the nasion has been added to facilitate the reading of the figure.

Fig. 5. The skull, reconstructed from the same negative as that from which Fig. 4 was made, together with the outline of the soft tissues, showing the result of the experiment, perhaps more strikingly than in Figure 4.

bodies were available for this purpose. Each student was permitted to carry out the necessary operations without any further instructions or interference from me. The results of this experiment may be read off from Table I, where + means that the nasion was accurately determined, and each figure the amount in millimeters from the nasion of the single observation it represents, the order of the observations being preserved for each student.

From this table it will be seen that the range of the average error of the nine students was from 0.5 to 1.8 mm. with an average total error for the 40 observations of 1.1 mm. The errors of the individual observations, however, run from 1 to 5 mm. Allowing for the inexperience of the investigators and the poorness of the material, the results were not at all bad. I feel quite confident if most of the investigators had put the head in the Frankfurt Plane and inserted the pick upon a plane horizontal to it through the tissues, the errors, small as they are, would have been appreciably reduced.

TABLE I

Student	Observations	Total Error	Av. Error
Kr.,	3, +, 3, 2, +	8	1.6
Gr.,	+, 5, +, +, +	5	1.0
Gi.,	2, 1, +, +, 2	5	1.0
Go.,	5, 1, +, 1, +	7	1.4
Su.,	+, +, 2, 2,	4	1.0
So.,	2, 2, 3, +	7	1.8
Ba.,	2, +, +, +	2	0.5
Da.,	+, 5, +, +	5	1.2
Ha.,	2, +, +, 1	3	0.7
9	Total 40	Total 46	Total Av. Error 1.1

It thus appears that the method above described for determining the nasion in the living is practically foolproof. It should be obvious, however, that it cannot be used on individuals with overhanging eyefolds or epicanthic folds.

I wish here to express my thanks to Professor Seth Hirsch, of New York University Medical College, for his kind advice and assistance in making the radiographs for this study.

A DEEP THERAPY TABLE WITH A TUBE STAND COMBINED AND REVOLVING IN ARC ABOUT THE TABLE: INTENSITY DISTRIBUTION WITHIN PARAFFIN PELVIS FOR VARIOUS PORTALS OF ENTRY

By NATHAN FLAX, M.D., Department of Roentgenology, Booth Memorial Hospital, *Covington, Ky.*

IN the irradiation of neoplasms of the cervix uteri and other mid-line tumors, a technic making use of the smallest of portals of entry, with a tube in constant motion, possesses distinct advantages. A small-port, moving-tube technic results in an unusually high depth dose with a low skin surface dose, and a great accuracy in directing the irradiation to the mid-pelvis. While the value of a high depth dose need not be stressed, the value of great precision in the distribution of the dose throughout the pelvis might be dwelt upon.

Proper "angles" at which the radiating beams traverse the pelvis are the basis of the cross-section irradiation charts, with the angles of the radiating beams so arranged as to insure the greatest cross-fire effect in the tumor area. Any deviation from the charted angle must cause an undesirable rearrangement of the intensity distribution within the pelvis, to the detriment of normal tissues and at the expense of tumor effect. Necessarily taken for granted is the ability of the operator to duplicate, by sighting the x-ray tube for an invisible tumor deep in the body, the angle called for in the chart for portals of entry. The small ports required with four-, six-, or seven-port technics, necessitate the most accurate direction, as an error of only a few degrees in angulation of the tube may result in a complete missing of a small, deep-seated invisible tumor, or if the tumor be too large to be missed altogether, the delivery of only the periphery of the x-ray beam into the tumor and a purposeless, if not injurious, irradiation of normal tissues.

On the other hand, a two-port technic, consisting of a single large port anteriorly and posteriorly, requires no precise angulation of the tube, and the distribution of the irradiation throughout the pelvis conforms to the charted value. Unfortunately, the depth dose is relatively small. It is felt that with this small-port, moving-tube technic, to be described here, a depth dose is achieved that compares advantageously to any multiple port technic available, and also possesses a precision of distribution of irradiation equal to the conventional two-port technic. This moving-tube technic makes use of a table and tube stand combined which are described as follows.

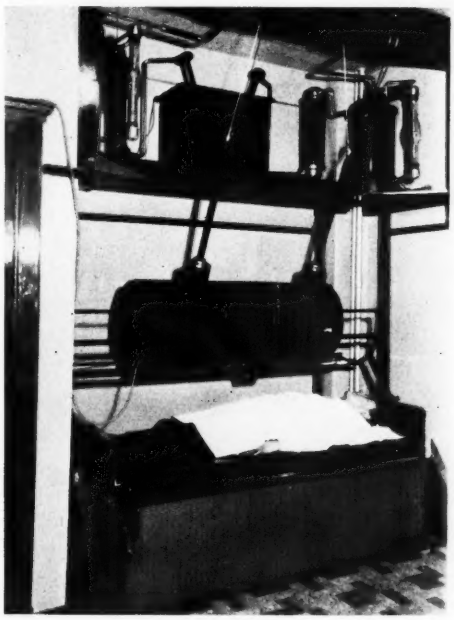

Fig. 1.

On a bearing at each end of the table is mounted the tube support for an air-cooled tube which can revolve about the table in an arc, the center of the radius of which arc is fixed and coincides with this bearing. The table top may be raised or lowered independently of the tube support, so that the patient may be raised or lowered to bring the tumor area into line with the

bearing which represents the center of the radius of the arc through which the tube moves. The tube itself is shifted on its mount, with the long axis of the body to enable its centering over any cross-section level of the body.

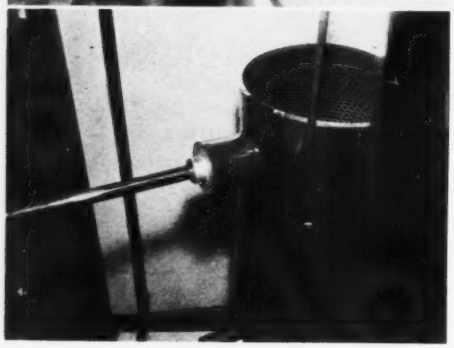

Fig. 1-*A* (*above*).
Fig. 1-*B* (*below*).

A motor under the table is geared to the bearing supporting the tube mount. Its speed is reduced through the interposition of a gear box, with worm reduction gears, so that the tube mount requires 20 minutes to travel through the half-revolution from one side of the table to the other in an arc about the patient supine or prone upon the table. In this manner, one-half of the patient's body surface is irradiated with one half-circle movement of the tube, and when the patient is turned over and the tube movement is repeated, the entire skin surface is irradiated, with the center of the body as a hub to receive portals of irradiation converging to the center throughout the entire movement of the tube. In effect, this continous movement of the tube makes constantly available new skin surfaces as portals of entry. Incidently, the tube is shockproof, and its slow movement is wellnigh imperceptible to the patient.

At first glance it might appear that this method of irradiation is fraught with danger to the skin, due to the constant overlapping of beams. However, closer scrutiny of the facts reveals that while there is a constant overlapping of beams, it is uniform, accurately controlled and easily measured, differing from that accidental overlapping which may occur in manually directed multiple port technics and for which accurate allowance cannot be made. Using a chunk of paraffin conforming in external contour to a female pelvis 23 cm. deep and 35 cm. wide, as established by Arneson and Quimby (RADIOLOGY, August, 1935), to be the size of the average female pelvis, the experimental values obtained revealed the spot surface dose to be considerably less than the dose in the center of the pelvis.

The following physical factors were utilized: 200 kv. p. Villard circuit; 0.5 mm. Cu and 1 mm. Al added filtration; 5 ma.; target-surface distance 58.5 cm. to the top of the pelvis and 52.5 cm. to the sides of the pelvis (the pelvis not being circular in shape, this variation in target-surface distance is unavoidable). Intensity distribution was charted with the following portals of entry: size in centimeters, 4 × 15, 9 × 15, 11 × 15, and 15 × 15, the greatest width of the portal concurring with the long axis of the body of which the pelvis was theoretically a part. It was found that at no time did the spot surface dose exceed the depth dose; with the largest portal 15 × 15, an intensity of 100 per cent could be delivered into the center of the pelvis, with 92 per cent as the greatest intensity over any spot on the surface; on the other hand, with the smallest portal, 4 × 15, the surface intensity for a depth intensity of 100 per cent was but 50 per cent. Were the surface ex-

posed to its full 100 per cent with a 4 × 15 cm. port, the depth dose would be 200 per cent.

around the pelvis in a half-circle, automatically the motor stopped and the x-ray turned off. In this manner readings were

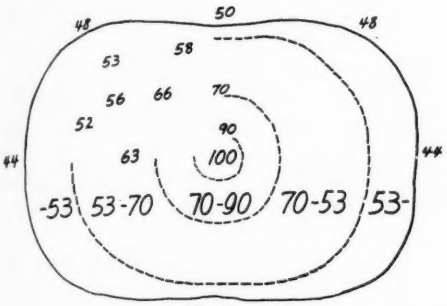

Fig. 2.

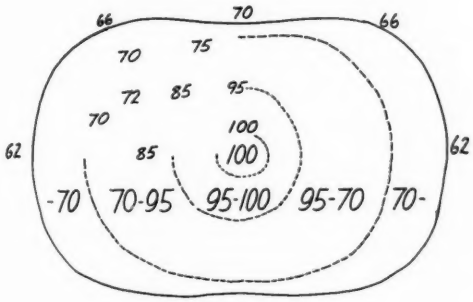

Fig. 3.

Fig. 2. Port 4 × 15 cm.; pelvis 23 × 35 cm.
Fig. 3. Port 9 × 15 cm.; pelvis 23 × 35 cm.

This last figure, checked and rechecked, is not to be wondered at if it is remembered that by dividing the available surface into areas 4 cm. wide, there would be approximately 24 such divisions, or, in its equivalent, 24 portals of entry. However, a portal as small as 4 × 15 cm. is interesting in point of theory, but it proves inefficient for a pelvis 23 × 35 cm., as will be seen later—a portal 9 × 15 cm., with a surface intensity of 70 per cent for a depth intensity of 100 per cent, proving itself more suitable for clinical application. A 9 × 15 cm. port is equivalent after a division of available surface to an 11-port technic. In point of execution, however, it is essentially a two-port technic, the tube travelling from one side to the other as a single port, and, with the pelvis turned, the other surface is irradiated as through a single port.

The values in Table I were obtained by placing the paraffin pelvis on the table with tube in the true lateral position, and the table top elevated until the depth center of the pelvis coincided with the radius center of the tube mount. No other adjustment was required. Simultaneously, with the full activation of the tube at 200 kv. p, the motor for moving the tube mount was started. When the tube mount reached the true lateral position on the opposite side, having passed

taken from a Victoreen, first, in the center of the pelvis for depth dose, and next, over five spaced areas on the upper surface. To these direct values were added the lesser back-scatter values that came through the pelvis when it was turned with the lower side up, and the ionization chamber on the down side.

It was expected that the values over the sides of the pelvis would be higher than the values over the upper and lower surfaces because the target-surface distance was 52.5 cm. to the sides, and 58.5 cm. to the top surface of the pelvis. Yet, the values on the lateral surface proved to be, in spite of the shorter focal distance, lower than the upper and lower surfaces. The most important cause for this interesting discrepancy lies in the fact that back-scatter on either side from its opposite side, 35 cm. removed, is considerably less than the back-scatter from top to bottom, 23 cm. removed.

While this discrepancy in values over the sides and upper surfaces is an inconsiderable one for the smaller portals of entry (Figs. 2 and 3), for values representing total spot skin intensity, the highest values obtained are tabulated in Table I. For depth intensity, the values obtained were the same with irradiation of either the upper or lower surface, and the figures

were likewise added to each other for total depth dose upon irradiation of both surfaces.

The reasons for the small surface intensity with a high depth intensity would appear to be as follows:

1. The utilization of every inch of regional surface, with consequent distribution of surface dose over a larger area; in methods of irradiation other than by mechanical contrivance to direct beam, it is unsafe not to have areas of skin between ports free from irradiation to prevent undue overlapping.

2. With the skin divided into 9 × 15 cm. divisions (the largest port size found feasible with this technic), the tube travels through 11 such divisions when revolving about a pelvis 23 × 35 cm. In spite of the skin dose per equivalent portal area being smaller, the increased number of portal areas available make for an increased depth dose.

3. The increase in tube-target distance from the usual 50 cm. to a distance varying from 52.5 to 58.5 cm., increases the depth dose. It is felt that this is the least of the factors involved, since the depth intensities could be increased by only a few per cent for this added distance.

Satisfied as to the margin of safety present for the skin, the distribution of intensity throughout points in the pelvis other than the center was next determined. Holes were drilled at various depth levels from the surface to the depth center in various planes, and into these the ionization chamber was inserted in succession. In order not to affect materially the bulk of the paraffin pelvis by the number of holes that had to be drilled, all the holes except the one into which the chamber was inserted for the particular reading were plugged by candles of equal diameter.

From Table I, it is evident that the smaller the portal the less the surface intensity required for a center pelvis intensity of 100 per cent, and as a result, the 4 × 15 cm. port would appear the most desirable. However, the measurement of points throughout the pelvis other than the center reveals a rapid falling off in values at points off-center with a port 4 × 15 cm., but a maintenance of high intensity in points off-center when a portal 9 × 15 cm. or larger is used. The explanation for this is self-evident: the center of the radius within the pelvis is not truly a point center but is an approximate area that corresponds in size to the width of the portal of entry. With the 4 × 15 cm. port the radius center would be about 4 cm. wide, and this only would be the area of maximum intensity. With a 9 × 15 cm. port, the radius center is approximately 9 cm. wide, accounting for the high intensity maintained in a larger area; continuing, the 11 × 15 cm. port yields an area of greatest intensity that includes almost the entire pelvis in its anteroposterior diameter. Thus, while the 4 × 15 cm. port yields too small an area of maximum intensity in the center of the torso, the 11 × 15 cm. port or larger, yields an area of maximum intensity too large and which encroaches upon the immediate subcutaneous areas with an intensity that is more than proportionately higher.

TABLE I.—MEASUREMENT OF r-UNIT INTENSITY SURFACE AND DEPTH CENTER OF PELVIS 23 × 35 CM. WITH ONE COMPLETE REVOLUTION* OF TUBE

Port (cm.)	r-units			Surface per cent Depth Intensity
	Surface**		Depth	
4 × 15	(4.0 + 0.5) =	4.5	9.0	50
9 × 15	(8.5 + 2.0) =	10.5	15.0	70
11 × 15	(10.5 + 3.0) =	13.5	16.0	84
15 × 15	(12.5 + 4.5) =	17.0	18.5	92

* Because of the number of readings required, motor was geared up so that tube revolved completely about table in six minutes instead of forty.

** (Direct point surface value + backscatter from irradiation of opposite side) = total point surface value.

A study of the distribution chart for a port 9 × 15 cm. (See Chart 3) reveals a radiation intensity distribution that appears satisfactory and advantageous. In the center of the pelvis, throughout an area approximately 11.0 cm. in diameter, the intensity is 100 per cent diminishing to 95 per cent peripherally. On the periphery

of a still larger area from the center radius, and 16 cm. in diameter, the intensity is still 85 per cent and from there out there is a gradual fading out peripherally toward the surface, the intensity of which is 70 per cent on the upper surface and 62 per cent on the lateral surface. We have, then, the greatest intensity in the potential tumor area and the least intensity in normal tissues. This is a highly desirable distribution of intensity and certainly an unusual one for irradiation of external surfaces where the usual distribution is one of 100 per cent on the surface with a diminution of intensity toward the center.

From these values it is apparent that for a pelvis of average size and an area to be irradiated located in the midline and center of the body, the portal of entry should not be larger than 9 × 15 cm., but that if the area requiring an intense irradiation permits, a smaller portal might be used profitably to spare even further the normal tissues. Because this technic enjoys its greatest advantage with smaller ports, one should endeavor at all times, if accurate localization of a tumor is possible, to use the smallest adequate port size. A tumor of the bronchus might best be irradiated with a port perhaps 6 × 15 cm., while a growth of the cervix uteri might require a portal 9 × 15 cm. Of equal importance to the small skin dose with high depth dose possible with a moving-tube technic is this ability to select a port size for a given pelvis size to achieve an intensity distribution that confines as much as possible the maximum intensity to the tumor area, or rather, to the direct topography and invasive characteristics of the tumor, sparing as much as possible the normal tissues. Under unusual circumstances, one might use a 9 × 15 cm. port over one surface and a 4 × 15 or 6 × 15 cm. port over the other surface. This may appear to be drawing the line too fine, since it involves a degree of localization not usually possible.

Regarding the actual r-unit delivery with the different portals of entry, by reference to Table I, it can be noted that, apart from the 4 × 15 cm. port, there is no great difference in quantity between ports 9 × 15, 11 × 15, or even 15 × 15 cm. For 15 r-units delivered into the center of the pelvis with a 9 × 15 cm. portal, only 16 r-units will be delivered for the same unit of time if the portal used is 11 × 15 cm., and only 18.5 r-units if the portal size is 15 × 15 cm. This difference would never influence decision in favor of a large portal because of an economic complication. From every point of view, the use of a portal 9 × 15 cm. is satisfactory for the pelvis of average size, and is considered the largest port to be used with this pelvis.

In a larger pelvis with a greater anteroposterior diameter and a greater centricity of the body, a port larger than 9 × 15 cm. might be used, perhaps 11 × 15 cm., depending on the size of the pelvis and the area to be irradiated. Conversely, with a pelvis smaller than 23 × 35 cm., a portal 9 × 15 cm. would be too large. This supposition was tested by reducing the size of the pelvis to 20 × 35 cm. and measuring the intensity distribution with a port 9 × 15 cm. (See Table II.)

TABLE II.—CENTER, OFF-CENTER, AND SURFACE INTENSITY IN PERCENTAGES

Portal (cm.)	Center	5.5 cm. Radius*	7.5 cm. Radius	9.5 cm. Radius	13 cm. Radius	Upper Surface	Lateral Surface
Pelvis 23 × 35 cm.							
4 × 15	100	70	63	58	53	50	42
9 × 15	100	95	85	75	70	70	62
11 × 15	100	104	100	100	84	84	66
Pelvis 20 × 35 cm.							
9 × 15	100	102	80	69	67	70	45

* The radius does not represent a true circle; it increases laterally following the configuration of the pelvis.

Because the area of greatest intensity does not occur in the center of a pelvis 20 × 35 cm. in size, when irradiated by a 9 × 12 cm. port (See Table II), there follows from this, the conclusion that the smaller the anteroposterior diameter, the smaller the portal to be used; that a pelvis smaller than 23 × 35 cm. requires the use of a portal smaller than 9 × 15 cm. Fur-

ther, the deduction appears feasible that with larger pelves, portals larger than 9 × 15 cm. can be used. Having established that portal of entry yielding a proper radiation distribution within a pelvis of average size, it now remains to be determined how much increase or diminution in portal size will be entailed in adapting this technic to every size of pelvis. Possibly a portal range from 6 × 15 cm. to 11 × 15 cm. will be found to suffice for all variations in size. Further study in this direction is planned, and also, the adaptability of this technic for creating areas of maximum intensity eccentric to the body axis. Here again, it will become a question of proper port size, and perhaps, combination of port sizes.

Pending this further study of pelves other than average in size, it is no great presumption to state that, although very thin pelves can be advantageously irradiated by this technic after the proper port size is determined, it is in the pelvis of greater than average rotundity and anteroposterior diameter that this technic will have its greatest applicability. This is a fortunate circumstance because the thin pelvis offers no great problem for its adequate irradiation with conventional technic; it is with the large pelvis that difficulty arises in the delivery of adequate depth intensity. With the patient's body more rotund, more skin surface is available for portals of entry, with unfortunately, the tumor more remote from the surface. Here most of all is it difficult to angle manually the small port for the deep, invisible tumor so that the extra skin surface cannot be properly utilized. In a moving-tube irradiation, the patient's bulk does not offset the advantage of increased skin surface for portals of entry, and it is felt that as great an intensity can be delivered into the depth center with small skin intensity.

Where beams converge there is overlapping, and the center of the pelvis being the point of greatest convergence, the greatest overlapping is there present, with the highest irradiation intensity. From the center of the pelvis outward to the periphery, the convergence and overlapping is lessened and the intensity is lessened, until, at the surface, the overlapping is least and hence the intensity least. Given a larger pelvis, the surface is farther from the center and the overlapping on surface and subcutaneous areas is less than on a small pelvis. The diminution in intensity of the individual beam that occurs with the greater depth is compensated for by the increased amount of skin available for portals.

From the point of view of economy of effort this unit proves of advantage. Instead of changing the tube inclinations for four or six ports, and slowly increasing the voltage each time to its maximum, the patient's set-up is that of a two-port technic, front and back. The tube is never adjusted to the patient. The table top is merely raised or lowered to bring the tumor area into the center of the tube radius required.

CONCLUSIONS

1. Through the use of a tube, moving in an arc about the patient, a high depth intensity with a small surface intensity is made possible.

2. A distribution of intensity is achieved wherein the center of the pelvis receives the greatest intensity, with the intensity diminishing peripherally to become the least great on the surface.

3. The size of the area of central intensity can be regulated by use of a proportionate portal size.

CASE REPORTS AND NEW DEVICES

SLIT SCANOGRAPHY

By ROBERT H. MILLWEE, M.D., *Dallas, Texas*

Two factors which add greatly to the difficulty of interpretation of radiographs are distortion and great variation in thickness or density of various anatomical parts included in single radiographs, as for instance, the toes and ankle, or regions adjacent to the diaphragm.

Much has been accomplished to minimize distortion and irregularity of density, by making multiple exposures from various angles and by the employment of greater plate-target distance.

With a view of further reducing the effects of distortion and variation of density we attempted during the past year the development of some new apparatus of unusual type. We were especially interested in the making of clear radiographs of large portions of the spine, which would more accurately portray the relation of its various parts. My first idea was to develop a method of shifting the tube up and down the spine, making a number of radiographs of small portions of the spine on the same plate in such a manner that they would fit together in a composite picture. The idea of moving the tube during exposure was considered, but not attempted, because of the probable loss of detail. Co-operation of the research department of the Kelley-Koett Company was secured, and an apparatus for the work was constructed under the direction of Mr. W. W. Mowry. Mr. Mowry also suggested moving the tube while exposure was being made, and he carried out some experiments. After analyzing the results of this work, our present apparatus was completed by the Kelley-Koett Company, and considerable experimentation has been carried out. The results are in some respects very encouraging, and we believe the idea has certain advantages which deserve the attention of the progressive radiologist.

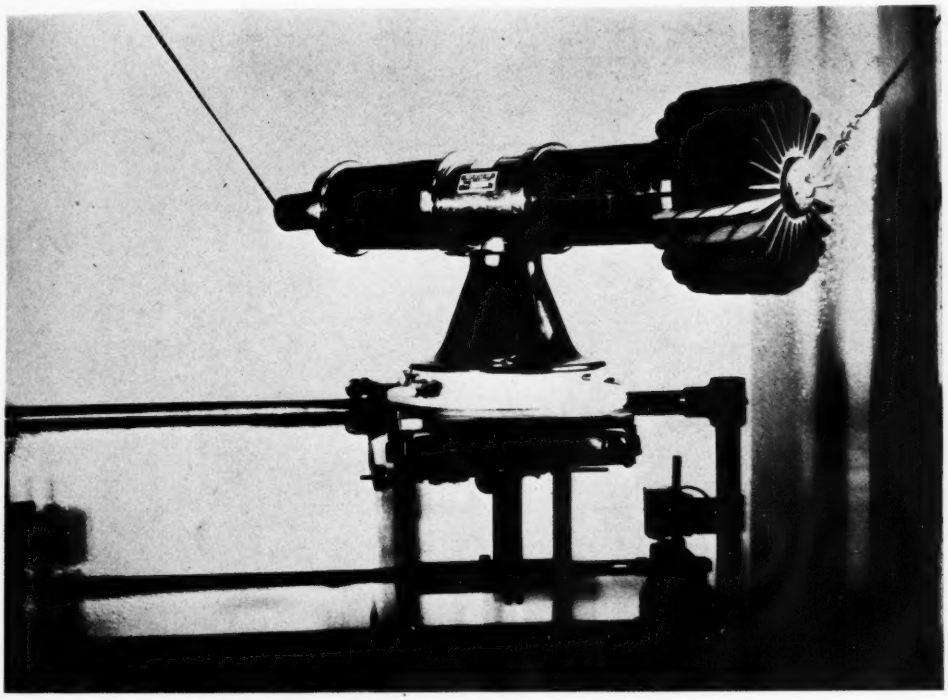

Fig. 1-*A*. Photograph of scanographic apparatus which shows the tube mounted on an arm above the table and the motor-driven screw which moves the tube lengthwise of the table.

The apparatus (Fig. 1) consists of a regular radiographic table with a side rail and arm to hold an x-ray tube at a plate-target distance

of 25 inches. This tube is driven lengthwise of the table at varying speeds by a motor-driven worm gear. Instead of the regular circular cone, an adjustable slit is arranged between the tube and patient to take the place of the cone. Hence, as a tube is passed from one end of the table to the other a beam of x-rays like a narrow sheet, or line of x-rays traverses the patient. In other words, the tube moves over the part to be radiographed while the exposure is being made. The apparatus is so arranged that all the plate is protected by lead, except that narrow strip which is being exposed. The protecting material is supported by an arm under the table top between the patient and the plate, and this is secured to the tube, moving at the same speed as the tube. This single slit serves the same purpose as a narrow Bucky in absorbing secondary rays. In this way all the central beam of x-rays passes through the body and reaches the plate from the same angle. Some of the radiographs made by this apparatus are found in Figures 2, 3, 4, and 5.

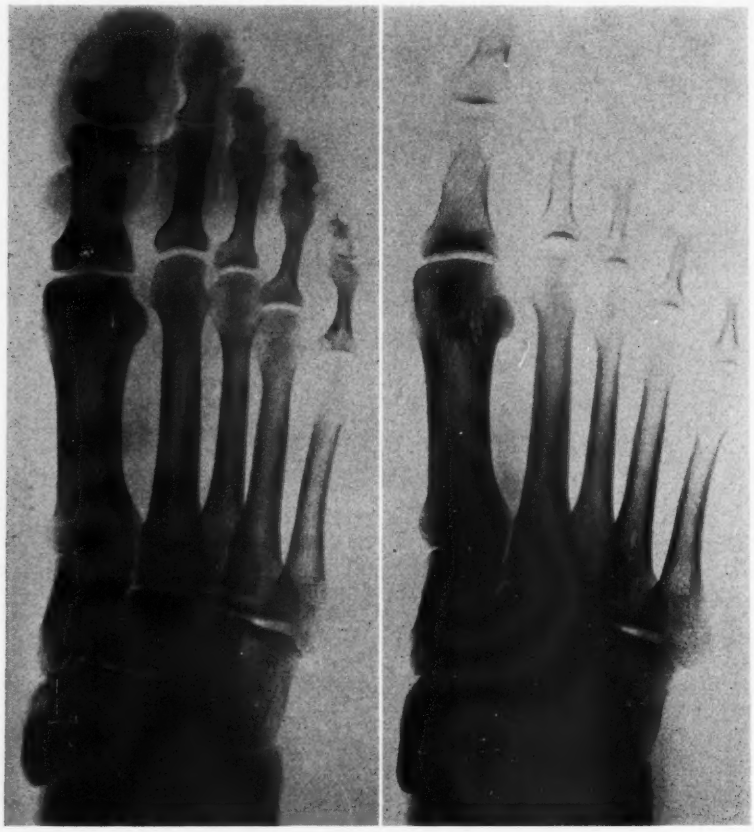

Fig. 2-*A*. Fig. 2-*B*.

Fig. 2-*A*. This is an ordinary radiograph, anteroposterior view, made to bring out the detail of the tarsal bones. Such a radiograph, as is usually the case, does not reveal much definition in the distal portion of the metatarsals and phalanges.

Fig. 2-*B*. Scanograph of the same foot as shown in Figure 2-*A*. As the tube travelled from the posterior to anterior portion of the foot, the voltage was decreased, which produced as good bone detail in the phalanges and thicker portion of the ankle.

The method has some advantages: First, an exact measurement of bones or joint spaces is secured, which is of great advantage in a study of bone or joint development; second, it aids in securing better radiographs of parts of the body which vary greatly in thickness or density.

It may give considerable valuable information regarding physiological or pathologic processes which affect the movement of parts or organs such as the heart, diaphragms, pleura,

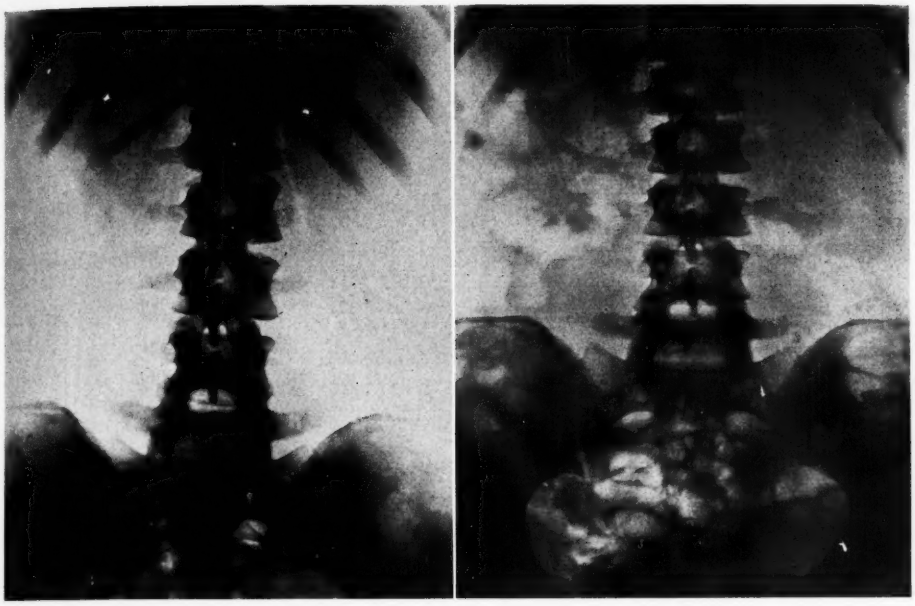

Fig. 3-*A*. Fig. 3-*B*.

Fig. 3-*A*. Ordinary anteroposterior radiograph of the lumbar spine which reveals the usual distortion.
Fig. 3-*B*. A scanograph of the same lumbar spine, the tube having been shifted lengthwise of the spine during exposure, which eliminates distortion in the vertical direction, giving the accurate vertical widths of the vertebral bodies and intervertebral spaces.

or chest wall, as are now studied by the kymographic method. Exact measurements of the heart, pelvic outlet, or fetal head are secured, all of which are difficult to obtain by other methods.

Foreign bodies may be more accurately located.

The exact extent of bone pathology may be more accurately determined.

Distortion in one direction is entirely eliminated by this method, so if radiographs are made by shifting the tube in one direction and then a second radiograph is made shifting the tube at a right-angle to the first shift, distortion is completely eliminated.

Further development of this idea may produce radiographs entirely void of distortion in all directions.

An excellent radiograph may be made of a part which varies greatly in thickness or density by varying the speed of the travelling rate of the tube, or by varying the voltage of current through the tube with variation of density of the part being radiographed.

I have given this method of making radiographs the name "Slit Scanography." The word "scanography" was suggested to me by Dr. Wendell G. Scott, of Washington Uni-

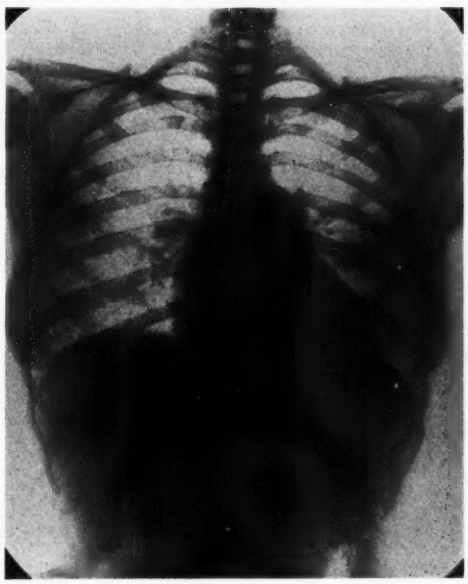

Fig. 4-*A*.

Fig. 4-*A*. An ordinary radiograph of a heart, which reveals a slight enlargement of the heart on the left side.

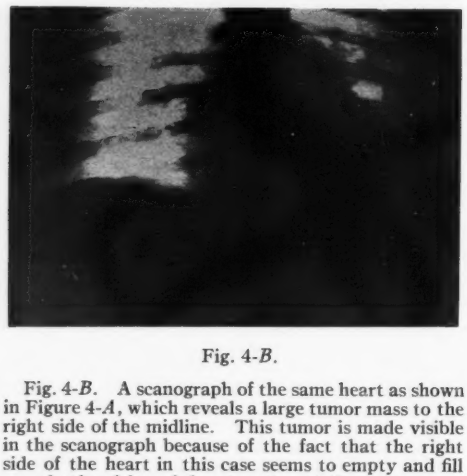

Fig. 4-*B*.

Fig. 4-*B*. A scanograph of the same heart as shown in Figure 4-*A*, which reveals a large tumor mass to the right side of the midline. This tumor is made visible in the scanograph because of the fact that the right side of the heart in this case seems to empty and fill completely with each heart cycle and the tumor mass does not empty. Hence the greater difference in density, which condition does not exist in the case of the ordinary radiograph. In other words, the variation in density during diastole and systole is recorded on the film. The left border of this heart moves, as recorded in the scanograph, but the variation in density of the heart and muscle on the left side is not recorded, as in the case on the right side in this heart. This patient was clinically a case of aortic stenosis; hence the lack of change of density of the left side of the heart, as shown in the scanograph may be due to either hypertrophy of the heart muscle on the left side or the heart may never become completely emptied of blood during systole, because of aortic stenosis.

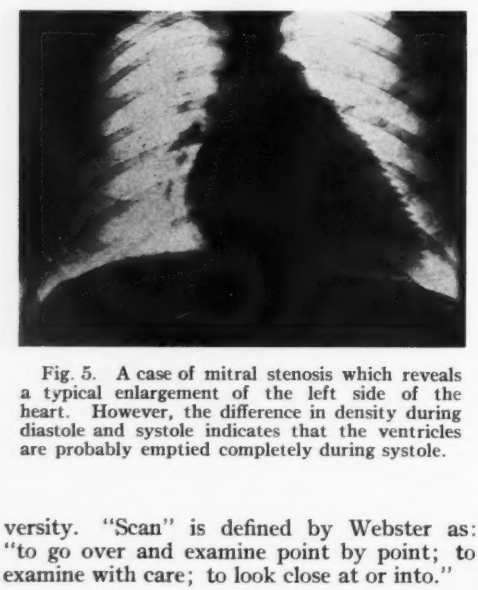

Fig. 5. A case of mitral stenosis which reveals a typical enlargement of the left side of the heart. However, the difference in density during diastole and systole indicates that the ventricles are probably emptied completely during systole.

versity. "Scan" is defined by Webster as: "to go over and examine point by point; to examine with care; to look close at or into."

Several difficulties must be overcome before scanography will be successfully employed for heavy parts like lateral views of lumbar spines, and one of these difficulties is the development of a tube of sufficient capacity. For instance, we need a tube to take 100, or preferably 200 ma. at 80 kv. for several seconds. We are now experimenting with the use of three tubes placed parallel with one another, with parallel slits, so that the distance which the tube must travel may be materially reduced. The great difficulty in this procedure is to avoid overlapping of rayed areas.

SARCOMA OF THE STOMACH

A REPORT OF TWO CASES

By WILLIAM S. MIDDLETON, M.D., *and* LESTER W. PAUL, M.D., *Madison, Wisc.*

From the Departments of Medicine and Radiology, University of Wisconsin

An extensive and scattered literature has grown about the subject of sarcoma of the stomach. The clinical diagnosis of this lesion remains the exception rather than the rule. Accordingly the following instances of sarcoma of the stomach are deemed worthy of record.

Case 1. W. M., a white male, 59 years old, was first admitted to the State of Wisconsin General Hospital on March 31, 1936. His present illness dated from March 19, 1936, at which time he passed a large tarry stool. He felt weak and had to go to bed. A physician was consulted and he advised a light diet and bed-rest. There was no pain, nausea, or vomiting. History by systems revealed occasional vertigo, tinnitus, palpitation, dyspnea, and fatigue. There had been a 20-pound weight loss within ten days. The past medical history evolved no pertinent findings.

On physical examination a marked pallor of the skin was noted. The pupils reacted poorly to light and accommodation. The heart was within the upper limits of normal in size. Aortic and mitral systolic murmurs were heard. The blood pressure was 150/90. The liver was palpable 6 cm. below the right costal margin.

The urinalysis was essentially normal. Blood study showed a hemoglobin of 48 per cent; red blood cells, 2,540,000; white blood cells, 7,200, with a normal differential count. The blood Wassermann reaction was negative.

A roentgen-ray examination after a barium enema showed a normal colon. A gastrointestinal series was commenced but the patient fainted before upright fluoroscopy could be completed and the examination was done largely with the patient in the recumbent

position. The esophagus was normal. There was a small area of translucency, brought out only by palpation, in the central portion of the stomach just below the incisura angularis and toward the greater curvature side. There was a break in peristalsis on the greater curvature opposite this area. The rugæ were markedly thickened in the central and distal portions of the stomach and in addition to the larger area of translucency, there were several smaller ones in the immediate vicinity. No ulcer crater could be demonstrated in the stomach or the duodenal bulb. The roentgenologic impression was that of polypoid lesions.

Following the completion of his diagnostic study the patient was discharged and later readmitted on May 5, 1936. He had regained strength in the interval and there had been no further hemorrhage from the bowel. An exploratory laparotomy was performed on May 14, 1936. A hard nodule was palpated through the gastric wall in about the mid-portion. An incision was made in the anterior wall of the stomach, a forceps introduced and the mass brought out through the opening in the stomach. Examination revealed a puckering of the mucosa at this point, which was felt to represent an ulcer scar. A gastric resection was then done followed by an entero-anastomosis after the Polya modification of the Billroth II type. The post-operative course was uneventful.

Examination of the excised portion of the stomach revealed a small superficial ulcer 5 mm. in diameter surrounded by localized hypertrophy of the mucosa. A firm nodule could be palpated beneath the ulcer and, on section, this appeared well circumscribed and about 1 cm. in diameter. Professor C. H. Bunting, of the Department of Pathology, has kindly reported his study of this tissue as follows:

"The section shows a lightly stained tumor mass apparently originating in the submucous coat. The tumor appears slowly growing but has invaded in both directions, extending inward into the mucosa and outward through the muscle coat into the subserous layer. The cellular content is somewhat variable. Certain cells are of spindle character, others are rather pleomorphic, with polyhedral tendency, with relatively large vesicular nucleus and distinct nucleolus; and with considerable deeply staining protoplasm with numerous minute punched-out vacuoles, apparently fat vacuoles. These resemble in appearance embryonic fat cells. Other cells are of a small signet-ring type. Our conclusion is that the tumor is of the nature of a liposarcoma."

Case 2. Mrs. K., a white female, 44 years old, was admitted to the State of Wisconsin General Hospital on April 16, 1936, complaining of pain in the left side of the abdomen. The pain had had a sudden onset on April 1, and a dull throbbing had persisted with alternately sharper pain in the left upper quadrant. On further questioning the patient stated that she had experienced some abdominal distress and dull epigastric pain with periods of exacerbation since 1908. An appendectomy had been performed in that year without relief of the symptoms. In 1927 cholecystectomy had been done and two stones were found in the gall bladder. At no time during this protracted history had there been hematemesis, but the stools were tarry on March 16, 1936. This blood loss continued for one week, but there has been no recurrence since. For the past ten years or more she had been on a modified Sippy diet from time to time. Weakness had advanced and since the middle of March, 1936, she had been confined to bed almost continuously.

At present the sharp pain which superseded the persistent dull throbbing pain in the left side was localized to an area about five centimeters in diameter in the left upper quadrant. It recurred a number of times a day. Such attacks lasted from five minutes to several hours. The point of the greatest intensity of the pain was several finger-breadths below the left costal margin in the mid-clavicular line and the pain seemed to traverse to the back. Hot applications offered some relief, but the exacerbations occurred without any known cause.

In the inventory by systems the only details of importance related to an unpleasant taste in the mouth, elaboration of the regular dietary and antacid regimen, indefinite nausea, inability to vomit, abdominal distention with generalized abdominal pain in the middle of March, belching and eructation of gas with the shifting of the localization of pain, as above stated, about April 1. Constipation had been met by the use of mineral oil. There had been weight loss of about eight pounds since March 15. The past medical history established the occurrence of scarlet fever with a complicating nephritis when ten years old, diphtheria shortly thereafter, cow pox in childhood, mumps, whooping cough, and pneumonia in childhood, tonsillitis with frequent quinsy prior to 1920 when tonsillectomy was performed. The social history was irrelevant. The history of the catamenia showed no abnormality except a recent reduction in the flow. The family history was important only in the detail of surgery directed toward peptic ulcer in a sister, 39 years old, who is now said to suffer from gall-bladder trouble.

The physical examination revealed the following pertinent findings: Rather poorly nourished, under-developed, pale white female,

several palpable axillary nodes, nasal turbinates enlarged, mucous membranes of the mouth pale, slight impairment of resonance posteriorly in the upper chest, diminution of the breath sounds at the apices, heart size normal, soft apical systolic murmur untransmitted, splinting of the left upper abdomen upon respiration with peculiar staying of the outward movements of the left costal margin, spasm of the left upper abdominal muscles, exquisite tenderness in the left flank, liver palpable 2 cm. below the costal margin, parous vaginal outlet with good support, retroverted uterus, thick creamy vaginal discharge.

Fig. 1.

Fig. 2.

Fig. 1. Case 2. Postero-anterior view of stomach. The upper third is blanched out from pressure of the mass posteriorly. The intact rugæ are on the anterior wall.

Fig. 2. Case 2. Anteroposterior view. There is evidence of external pressure on the stomach with nodular protrusions into the lumen. Small gas bubbles are seen in the soft tissue mass outside of the gastric lumen.

Gastro-intestinal observations were reported as follows: the barium meal passes through the esophagus without delay. The fundus of the stomach shows a mottled defect limited to a rather small area on the posterior wall and with an associated mass lying posterior to the fundus and compressing it considerably. This region corresponds to the area of maximum tenderness. The balance of the stomach fills normally. The bulb fills immediately and shows normal outline. The films show a stomach of normal size. There is blanching of the barium shadow in the upper third due to the presence of the mass posterior to the fundus and a mottled defect involving the posterior wall and adjacent portion of the lesser curvature just below the cardiac orifice. No ulcer pockets are visible. The bulb is normal and immediate emptying is satisfactory. In six hours the stomach is empty of barium and the head of the meal is in the proximal transverse colon. Progress through the small intestine has been quite satisfactory. There are mottled air shadows in the region of the middle third of the stomach with rather a peculiar distribution. These shadows are persistent in all films.

The urinalysis was essentially normal. The blood count showed a hemoglobin of 55 per cent, red blood cells 3,720,000, white blood cells 8,200 with 83 per cent neutrophiles and 17 per cent small lymphocytes. The stools were negative to guaiac. The blood Wassermann reaction was negative. Blood chemistry revealed normal values for glucose and nonprotein nitrogen.

The differential diagnosis lay between a perforating peptic ulcer on the posterior wall of the cardiac end of the stomach and a neoplasm in this location and, interestingly, the clinical opinion favored a perforating ulcer, while the roentgenologic judgment was carcinoma of the stomach with necrosis.

In either event, surgical interference was deemed imperative and accordingly four days after discharge from the State of Wisconsin General Hospital, Dr. O. E. Satter, of Prairie du Chien, performed a laparotomy with the following results: On the greater curvature of the stomach about three inches from the cardiac orifice there was found a malignant diverticulous mass about three and one-half inches in diameter. The omentum was drawn down around the mass to wall off a recent partial perforation. There seemed to be an actual outgrowth from the posterior curvature of the stomach that admitted two fingers and then dilated into a necrotic cavity. This diverticulous mass was excised from the stomach wall and the opening into the stomach closed. The patient succumbed shortly thereafter.

Professor C. H. Bunting has kindly rendered the following histologic description and opinion:

"The section of the stomach wall shows an extensive chronic ulcer, subtended by granulation tissue with a superficial, quite dense, fibrinous exudate. At many points there is invasion of the ulcer base by tumor cells of a spindle shape. These are grouped in many places in a palisade arrangement suggestive of the picture presented by a neurogenic sarcoma. However, deeper in the stomach wall the tumor consists of interlacing bands of spindle cells without the palisade arrangement but grouped in interlacing bundles. In certain areas these cells are continuous with more normal bundles of smooth muscle cells, and it is concluded that the tumor is of this order and to be diagnosed as a myosarcoma, of origin in the muscle coat and with marked invasion throughout the layers of the stomach wall."

DISCUSSION

Essentially these two patients presented distinctly different clinical pictures. Melena occurred in both. While this symptom dominated the picture in Case 1, it was subsidiary in Case 2. The recent order and severity of the gastro-intestinal hemorrhage characterized Case 1. In Case 2, pain of an altered type had suddenly supervened in a patient who for years had experienced abdominal distress and epigastric pain. The nature and reference of the recent pain in the left upper quadrant of the abdomen had suggested the clinical diagnosis of a perforating gastric ulcer in the posterior wall of the stomach.

In the light of subsequent developments, the roentgenologic findings are of especial significance. In Case 1, syncope rendered an adequate examination impossible, but an area of translucency in the central portion of the stomach developed by pressure led to the conclusion of a gastric polyp. This opinion was strengthened by the occurrence of several smaller areas of translucency adjacent to the one described. The roentgenologic findings in Case 2 were even more arresting. The filling defect in the posterior wall of the fundus was associated with a mass and the intragastric protrusion of the same led to a division and diversion of the barium meal as it entered the stomach. The mottled air shadows which persisted at the site of the palpated mass gave force to the suggestion of a necrotic tumor in communication with the stomach. No explanation for the failure of barium to enter such a pathway was offered at the time of the examination. It is significant, however, that the clinical staff favored an inflammatory background while the roentgenologist maintained a neoplastic diagnosis. Drane's comment in this relation (1) is particularly pertinent: "The roentgenologist was the first to definitely palpate a mass. He was in error in saying that it was a carcinoma and inoperable, but correct in maintaining that it was malignant and not a perforated ulcer with inflammatory mass deforming the stomach."

Admittedly in the present state of our knowledge of the subject the accurate clinical diagnosis of sarcoma of the stomach is the unusual exception. As a rule the symptoms, clinical course, and physical findings conclude a diagnosis of gastric carcinoma unless there be a more or less removed but recognized lymphosarcoma with subsequent evidences of involvement of the stomach. So remote is the chance of the clinical diagnosis of a primary sarcoma of the stomach, and yet so important from the standpoint of prognosis and management is its recognition, that every effort should be exerted to improve our diagnostic facility in this condition.

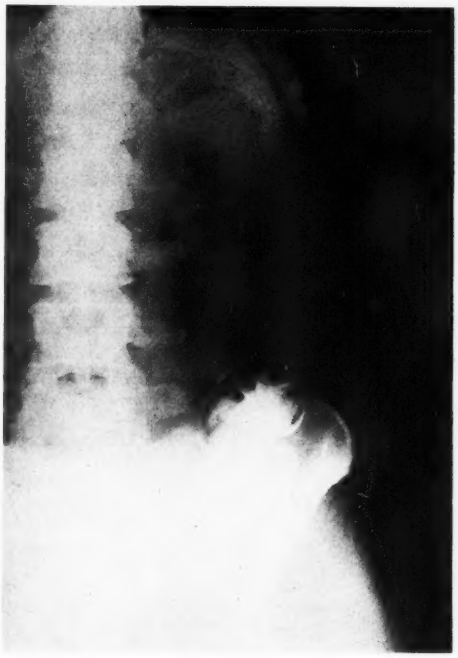

Fig. 3. Case 2. Multiple small gas bubbles visible in the region of the tumor considered indicative of necrosis within the mass.

Since roentgen examination apparently offers the only immediate prospect of assistance in this direction, we may with profit consider certain of the details which promise diagnostic advantage. D'Aunoy and Zoeller (2) conclude that "x-ray examination will usually furnish evidences of a gastric neoplasm but does not

give information enabling a positive diagnosis of sarcoma." Balfour and McCann (3) report the roentgenologic examination of 45 cases of sarcoma of the stomach in which the conclusions were: malignant lesion, 35; ulcer, 5; extra-gastric tumor, 2; possible benign tumor, 1; negative, 5. Importantly, they report operability in two of eight patients adjudged inoperable by roentgen examination. Two pre-operative diagnoses of sarcoma of the stomach were rendered and one roentgen diagnosis of lymphosarcoma was confirmed at operation. However, no guideposts are offered for this conclusion. Kessler (4) suggests that, in general, gastric sarcoma is not susceptible of regular roentgenologic diagnosis. She excepted the exogastric type of sarcoma which might conceivably lead to a large pressure defect in the stomach. Pack and McNeer (5) point out the improbability of obstruction of the orifices of the stomach by sarcomatous lesions in contrast to the proclivity of carcinomas in this direction. They furthermore indicate the directional significance of giant rugæ in lymphosarcoma and of the persistence of gastric peristalsis in the presence of a recognized lesion. Case (6) recently reviewed the reported instances of diverticulous sarcoma of the stomach (three) and added a case of his own, in which a diagnosis of "an ulcerating lesion with tumor formation" was made from the roentgen findings of a half-inch crater in the middle third of the stomach surrounded by a filling defect. Our Case 2 adds the persistent mottling of air bubbles at the site of the palpated mass to the filling defect and evident intragastric protrusion as meager supportive details for the diagnosis of this unusual condition of diverticulous sarcoma.

CONCLUSIONS

Two cases of sarcoma of the stomach are recorded in the hope of stimulating a concerted movement toward a registry of cases of this type. While our interest is primarily diagnostic, the prognosis of this neoplasm adequately treated is definitely better than that of gastric carcinoma. Hence it would appear logical to seek an earlier and clearer differential diagnosis between these confusing pictures.

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OXYCEPHALY

REPORT OF CASE

By DAVID BENNETT DAVIS, M.D.,
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Since Van Graefe, in 1886, first recognized and described this uncommon anomaly of the skull, much has been written concerning its various phases, and many cases have been reported. Noteworthy contributions to the literature of oxycephaly have been made in recent years by Grieg, Schuller, Bronfenbrenner, Jacobsen, and Fletcher. It is only because of the paucity of mention of this condition in the roentgenologic literature that this case is being presented.

Oxycephaly is a skull deformity secondary to premature synostosis of the cranial sutures. Normally these sutures are not obliterated until the sixth or seventh decades of life. When this fusion of cranial bones occurs in intra-uterine life, or in the first year of post-fetal life, the skull is prevented from growing and expanding in the usual normal manner. Instead, due to the inherent growth pressure of the brain, it expands at the points of least resistance (usually the anterior fontanel), and gives rise in time to a skull deformity with more or less definite morphologic characteristics.

The typical oxycephalic head is abnormally high, with a steeply rising forehead and a blunt, domelike apex at the site of the anterior fontanel. The globella, supra-orbital ridges, and frontal eminences are flattened out. There is usually a widening of the transverse and a narrowing of the anteroposterior diameter of the skull. Exophthalmos is a common feature due to a shortening of the anteroposterior diameter of the orbits. This is frequently associated with a divergent squint.

According to Jacobsen,

> "The occipit is almost flat. The forehead is flat or may even appear concave, with small superciliary ridges. The temporal regions bulge. The orbital openings are wide but the cavities are shallow, causing the eyeballs to protrude. The maxillary and zygomatic bones are poorly developed and the palate is highly arched. The body of the mandible may be strongly formed but the ascending ramus, neck, and condyle are under-developed. The teeth are crowded because of the narrow palate, and mouth breathing usually results from the malformation of the rhinopharynx. The accessary nasal sinuses are small or absent."

REPORT OF CASE

W. B., colored male, aged 9 years, was admitted to John Gaston Hospital on Aug. 20, 1936, with complaint of a peculiarly shaped head since one year of age, and of backwardness at school. A "tumor" was first noticed on the child's head when he was one year of age. This had grown progressively larger and more prominent. The boy was not as bright as his brothers and sisters. He has gone to school since he was six years old, and now, at the age of nine, he is still in the first grade.

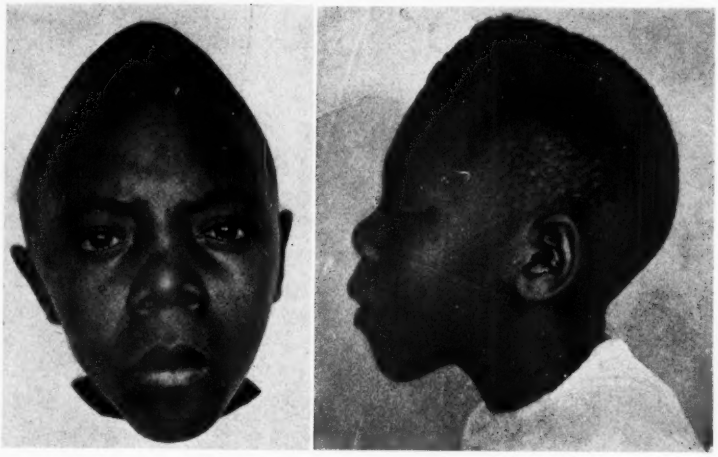


Fig. 1. Frontal and lateral photographs of patient.

Birth History.—Normal, full term, spontaneous, no instruments; weight seven pounds, six ounces; condition good.

Developmental History.—Bottle-fed; sat up at six months, stood at eleven months, talked at one year; first teeth at four months.

Family History.—Mother living and well. Father dead, of dropsy, at age of 50. Two brothers and one sister living and well; all normal. Family denies venereal history; no history of similar cases in family.

Past History.—Measles at eight years, whooping cough at two years.

Physical Examination.—Patient is a fairly well nourished colored male, aged 9; height $52^1/_4$ inches; weight $60^1/_2$ pounds; rational, co-operative, and friendly. He is, as Courbon has described a case of his, "calm, docile, apathetic, and indifferent." His response to questioning is slightly delayed but shows clarity of thought. His reactions to his surroundings are not those of a normal boy. At nine years of age, he is in the first grade at school, knows the alphabet, and can write his name. He talks with a nasal twang to his voice. He is apparently a mouth-breather. The head is shaped much like an egg, widest at the occiput and tapering symmetrically to a narrow, pointed chin. The unusual height of the head and a large dome-like mound at the site of the anterior fontanel are its most striking characteristics. The glabella, supraciliary arches, and frontal eminences are markedly smoothed out. The forehead rises at an angle of about 45 degrees and slopes steeply upward toward the bregma. At the site of the anterior fontanel is a large bony knob about the size of half a golf ball which marks the highest point of the skull. Along the course of the metopic, coronal, and sagittal sutures, definite raised ridges may be felt (Fig. 1).

MEASUREMENTS OF THE HEAD

Circumference	53.0 cm.
External auditory meatus to external auditory meatus	37.5 cm.
Inion to occipital point	5. cm.
Forehead to occipital point (calipers)	21. cm.
Inion to occipital point (calipers)	5. cm.
Biparietal width (calipers)	17. cm.
Bizygomatic width (calipers)	13. cm.
Basi-bregmatic height (from roentgenograms)	18. cm.
Basi-alveolar length (from roentgenograms)	9.3 cm.

Cephalic index: $\frac{\text{Breadth} \times 100}{\text{length}}$ $\frac{17 \times 100}{21}$ 80.9—brachycephalic or short-headed.

Horizontal index of normal head is 80.0; above that, is in brachycephalic or short-headed group.

Vertical index: $\frac{\text{Height} \times 100}{\text{length}}$ $\frac{18 \times 100}{21}$ 85.2—hypsocephalic or high-headed.

Vertical index of normal head is 70.0; above this, is in the high-headed group.

There is a difinite bilateral, symmetrical exophthalmos, but no strabismus. Extraocular muscles are normal. There is no limitation of the fields of vision. Pupils are equal and regular and react to light and accommoda

Fig. 2. Frontal and lateral roentgenograms.

tion. Examination of the fundi reveals only slight tortuosity of the vessels and no evidence of optic atrophy. Ears are normal. The bridge of the nose is flat and broad, the alæ nasæ fleshy. The teeth are carious; uppers slightly crowded but there is no overlapping. The palate is high, arched, and the pharynx is narrow and small. There is no cervical adenopathy. Thyroid is not palpable. Thorax is asthenic, asymmetrical, with a funnel type of chest. The right sternoclavicular junction is marked by a large knob, the size of a small walnut, and there is prominent beading of the upper five costochondral junctions on the right side.

The lungs are clear; the heart is normal. The rest of the physical examination and the neurological examination are essentially normal.

LABORATORY FINDINGS

Blood:
Red blood cells, 4,490,000
White blood cells, 4,200
Polymorphonuclears, 71 per cent
Polymorphonuclear eosinophiles, 2 per cent
Polymorphonuclear basophiles, 1 per cent
Lymphocytes, 25 per cent
Monocytes, 1 per cent
Hemoglobin, 14.4 per cent
Wassermann test, negative

BLOOD CHEMISTRY

Cholesterol, 153.0 mgm./100 c.c. serum
Non-protein nitrogen, 17 mgm./100 c.c. serum
Sugar, 84 mgm./100 c.c. serum
Calcium, 9.0 mgm./100 c.c. serum
Phosphorus, 4.2 mgm./100 c.c. serum
Urine, negative
Spinal fluid, pressure increased
cell count—2—lymphocytes
Pandy—negative
Kahn—negative

X-RAY REPORT (FIG. 2)

(1) Synostosis of all the bones of the calvarium resulting in

(*a*) Marked increase in height of skull and moderate increase in width.

(*b*) Extension of middle fossa downward and forward.

(*c*) Shortening of anteroposterior diameter of orbital fossæ and increase in their angle of divergence due to pressure from middle and anterior fossæ.

(*d*) Encroachment upon frontal, ethmoid,

and mastoid sinuses, with impaired development or narrowing of these sinuses.

(2) Sequelæ of increased intracranial pressure, namely,

(*a*) Deep convolutional digitations in all skull bones.

(*b*) Extensive thinning of calvarium, more marked at points of least resistance, *i.e.*, anterior fontanel.

Dr. Francis Murphey, neuro-surgeon in attendance, advised right subtemporal decompression. This was done on Aug. 27, 1936, under ether anesthesia. Recovery was uneventful and the patient left the Hospital on Sept. 6, 1936, in good condition. Seen at subsequent visits, the patient's condition is satisfactory and presents no significant clinical change although the mother claims that the child is much more alert and active since the operation.

CONCLUSIONS

Striking cases of premature synostosis of cranial sutures such as the one herein reported are not likely to go undiagnosed. However, it would seem probable that many of the milder cases are overlooked, especially those developing late, in which the deformity is mild and in which a thick head of hair may mask the picture. Unexplained exophthalmos, with even slight skull deformity or divergent squint, should be sufficient to excite suspicion and to justify obtaining x-ray plates of the skull in order to rule out oxycephaly.

LAMINATED KIDNEY STONES

By D. R. HANLEY, B.S., M.D., Roentgenologist, St. Mary's Hospital, *Streator, Illinois*

After an extensive survey of the entire medical literature I have been unable to find a single contribution in respect to laminated kidney stones. Whether or not this is the first case reported, is of no great consequence; however, such stones constitute a rare finding. Laminated kidney stones are referred to in certain texts, but they all show cross-sections of the stones with laminations internally, none showing their true organic nature throughout. Instead, their true organic matter is overshadowed by some crystalline substance. These stones present lamination not only internally but externally as well.

There is no insurmountable difficulty in explaining the growth of such stones when once started, but it is more difficult to explain their origin. Some are formed around foreign bodies, etc., but most calculi, whether found in the renal pelvis or in the bladder, are formed originally in the tubules of the kidney. This is especially true of uric acid stones, because they are the most common and because the conditions found in the so-called uric-acid infarcts of the kidneys explain their origin fairly well. These infarcts are found frequently in the kidneys of children, and produce a yellow streaking of the papilla of the pyramids and sometimes have actual stony concretions embedded in ragged cavities near the tip. This is due to the abundant excretions of uric acid by the cells of the tubules. The uric acid appears in minute, round spheroliths which becomes massed together with an albuminous material, secondarily gluing them together, forming the primary concretion.

The application of new layers of crystals to the concretion already formed is thought to occur just as rock candy crystallizes on the string; but it involves the idea of an oversaturation of urine with crystalline substances in solution. So, if the urine is acid, boric acid may crystallize out, while if it is alkaline, phosphates, ammonio-magnesium phosphates, and ammonium urates may appear. Something may cause the precipitation of those colloid materials in the urine which tends to hold the uric acid in solution, after which it produces ammonical decompositions of the urine, and is favorable to the formation of phosphatic concretions.

CASE REPORT

The following data are in detail from the patient's history as taken by the interne on the urological service with an admitting room diagnosis of pyeloliathiasis.

Patient J. M. J., single, white, American male, weighing 175 pounds, age 27 years, and a machinist by occupation. The patient stated that he was well and working every day until March, 1932, when he was stricken with a sudden pain on the left side below the ribs. The pain was knife-like in character and was exaggerated greatly when the patient was stooping or bending. Unable to go to work, he went to bed; the following day he seemed to be distended and was in more pain. The family physician was called, and he made a diagnosis of possible intestinal obstruction, advising hospitalization. This disturbed the patient greatly, but he refused to go to the hospital. He remained in this state for about two months, although he felt well enough to return to work. Following a New Year's Eve orgy he was stricken with a severe pain in the left upper quadrant and on New Year's Day was taken to the hospital by ambulance.

History by Systems.—Cardio-vascular, essentially negative; *genito-urinary*, no discharge;

Fig. 1. Flat plate with an opaque catheter in right ureter. Also two large laminated stones in the left kidney with several small non-laminated stones.

venereal infection denied; difficulty in starting and stopping the stream; stream starting in jerks with loss of parabolic curve. Nocturia from two to six times, with a day urination of from five to six times. Some hematuria. A history of catherization for retention. History also shows the usual childhood diseases. The family history carried no significance in respect to this case.

Blood pressure, 152/110; temperature, 99.4 degrees; pulse, 60; respiration, 20. The head, neck, heart, and lungs were found essentially negative upon examination.

The abdomen revealed marked tenderness in the left upper quadrant. There was a palpable mass in this area which was quite firm and adhered fairly well to the contour of the left kidney. No evidence of rigidity. Extremities and reflexes were essentially negative.

A blood and urine examination revealed the following information:

Blood Analysis	Urine Analysis
Hemoglobin, 85 per cent	Straw-colored
Red blood cells, 4,500,000	Specific gravity, 1.020
White blood cells, 8,250	Alkaline
Polymorphonuclears, 70 per cent	Few red blood cells
	Albumin, 1+
Lymphocytes (large and small), 25 per cent	Acetone, negative
	Diacetic, negative
Monocytes, 5 per cent	Urea nitrogen, 24.75
Cells counted, 100	Creatinine, 1.83
Wassermann test, negative	

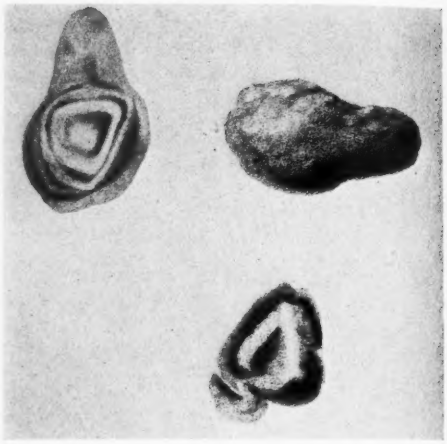


Fig. 2. Artist's drawing of the two large laminated kidney stones. The upper stone is shown in two views, while the lower and smaller stone shows only the face.

Five days after admittance the patient was cystoscoped. The right side showed a normal phenosulphonephthalein, with a negative catherized urine specimen. The left side showed no phenosulphonephthalein function; there was some pus present, epithelial and red blood cells. The urine was scant, even to the extent of only an occasional drop. Two cultures showed a growth of *B. coli*. A No. 21 F cystoscope was passed, the bladder containing 15 ounces of muddy urine with numerous large shreds. The bladder mucosa revealed multiple areas of crusty formation, marked trabeculations with sub-acute inflammatory infection. Catheters passed into the right kidney with ease, while on the left side the catheter met obstruction at the uretero-pelvic junction. The left ureter was markedly inflamed.

Four days after cystoscopy the patient expired of bronchopneumonia and an impending uremia.

Roentgen examination following retrograde pyelography showed the right kidney and ureter to be within normal limits. The left kidney showed dye in the ureter only, which was moderately dilated. The left kidney was enlarged and showed two large laminated kidney stones. An intravenous pyelogram revealed no additional information.

The stones grossly were hard, fairly smooth, but angular, conforming to or molded to the cavity in the renal parenchyma and pelvis containing them. The stones were quite large

and well formed, lending evidence of many months consumed in their formation. The appearance of the stones was as shown in Figures 1 and 2.

A laboratory analysis of the stones proved them to consist of uric acid, calcium phosphate, and ammonium urates. Each stone contained a single nucleus which gave a positive test for uric acid and xanthin; the laminæ gave positive calcium tests, while the remainder was composed largely of urates.

As can be noted from the history of this patient, there is nothing in his mode of living, type of work or rank of society to warrant his having laminated kidney stones instead of the ordinary variety of kidney stones.

A NEW POSITION FOR THE EXAMINATION OF THE LUMBOSACRAL AREA[1]

By GAGE CLEMENT, M.D., Radiologist, St. Luke's Hospital, *Duluth, Minnesota*

Ordinarily, in the x-ray examination of the lumbosacral area, the patient assumes a recumbent position on the table. Stereo films in the anteroposterior position, flat films in the two three-quarters oblique positions, and a flat film in the lateral position are probably

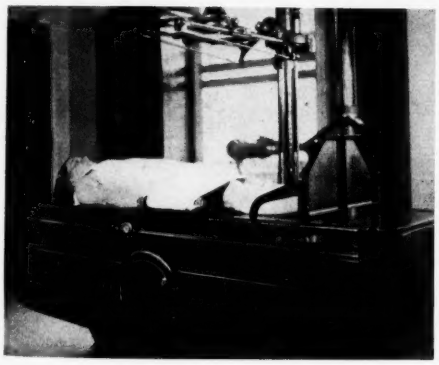


Fig. 1. Patient in usual recumbent position.

made. In none of these positions is there any resemblance to the position assumed by the patient while at work, either sitting or standing. This is particularly true in those cases of rather obscure or indefinite back pain. Such recumbent positions do not record the relationship which the bony structures assume with the patient upright and possibly lifting.

[1] Presented before the Radiological Society of North America at the Twenty-second Annual Meeting, at Cincinnati, Nov. 30–Dec. 4, 1936.

With this observation in mind, several plans were attempted with the object of revealing the changes which the upright position might produce. All the attempts failed except one, that of having the patient stand, strapped to

Fig. 2. Patient in upright position with sand bags on shoulders.

the table, supporting a 25-pound sand bag on each shoulder. This is the plan in use to-day.

The technic is as follows: The patient is placed in the usual recumbent position on the x-ray table. His feet are against the foot rest. The compression band is secured across the middle of the thighs and tightened. The tube is placed as nearly as possible over the central part of the upper pelvis, determined by centering over the middle of a line drawn from one anterior superior iliac spine to the other. The central beam is directed to it at right-angles. The center of the movable grid is placed in the path of the central beam and the cassette is placed in the center of the grid pan. In this position the first film, a flat anteroposterior exposure, is made. Without allowing the patient to move, the table is now raised to the upright position, the tube is centered exactly as before, maintaining the same tube distance. The grid and the cassette are again centered. The sand bags are placed on the patient's shoulders and this is done none too gently. He

is encouraged to relax, using only such muscles as are required to maintain the upright position. The second exposure is then made. This position requires a little longer exposure than the upright position does on account of an increase in the amount of soft tissue in and around the pelvis. In both positions, either anteroposterior or lateral exposures may be made, or both.

In the use of this technic four things must be done diligently: the tube distance must be constant; the relative positions of the tube, patient's pelvis, and the cassette must be constant; the compression band must be below the pelvis, and the patient must carry the weight of the sand bags. After processing, the films are viewed side by side or superimposed.

This method is not intended to replace the usual examinations of the lumbosacral region from which a diagnosis of organic pathology is desired. It is not intended as an aid in the diagnosis of bone and joint disease, but it is intended as a functional diagnostic method. It applies particularly to some of those patients presenting lower back pain in whom roentgenograms, taken in the ordinary manner, show no organic pathology. Among the abnormalities already found by this method have been sacroiliac subluxations, marked change in the position of the fifth lumbar body, separation of the symphysis pubis, compression of the intervertebral disc between the fifth lumbar body and the sacrum, and ptosis of one or both kidneys. Of all the patients examined in this

Fig. 3. Fig. 4.

Figs. 3 and 4. Changes in position of fifth lumbar body: 5 mm. downward displacement of sacrum.

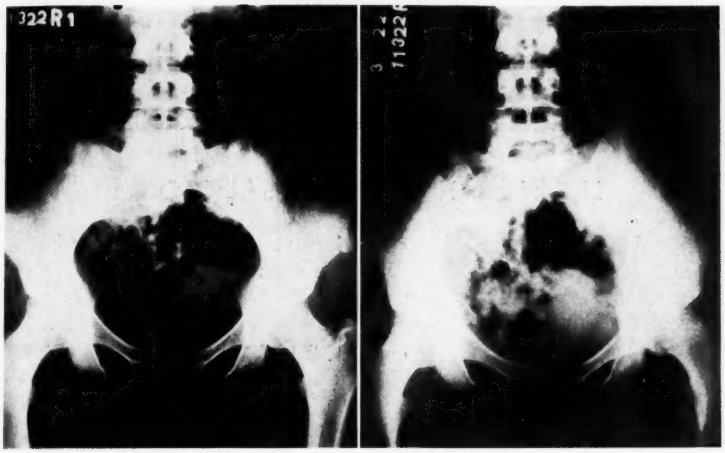


Fig. 5. Slight change in position of fifth lumbar body. Separation four displacement of pubic bones.

manner, less than 15 per cent showed evidence of abnormality. The procedure described is not recommended as a routine procedure but as a special examination in special cases.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

LIFE INSURANCE AND THE RADIOLOGIST

A young radiologist recently applied to one of the larger insurance companies for a life insurance contract including waiver of premium disability and accidental death clauses. The life contract including the waiver of premium clause was issued without question but the applicant was informed that the accidental death clause could not be granted because of his "line of work." An investigation revealed that this same company issues life insurance contracts, including waiver of premium disability, disability income and accidental death clauses without restriction, to physicians, surgeons, and dentists who use x-ray machines in their practice. One would naturally presume that this discrimination against radiologists was based on experience data to justify it. When information concerning their experience with radiologists as insurance risks was requested it was admitted that there was not sufficient volume and the matter would be too heterogeneous to withstand analytical criticism. Information concerning the underwriting practice of six other large insurance companies revealed that with one exception all granted life insurance contracts including waiver of premium and accidental death clauses at standard rates to physicians and surgeons using x-rays incidentally in their practice. All of these companies consider the radiologist a standard risk for straight life insurance but only three allow the radiologist a waiver of premium clause at standard rates. Two companies will not allow a waiver of premium clause for the radiologist and another company charges a radiologist double the rate for this feature. In regard to the accidental death clause, three companies provide it at standard rates for a radiologist, one charges double the rate, another charges one and one-half times the standard rate, and a third will not allow this feature. Since one of the standard insurance handbooks lists 68 life insurance companies in this country, the above practices cannot be considered a fair average of the entire group. They do indicate, however, that as far as seven of the largest companies are concerned, there is no consistent practice regarding the granting of waiver of premium and accidental death clauses to radiologists. It is doubtful if the experience of the companies represented can be so variable since the risk is relatively the same for each one. It is evident that most companies consider their experience tables confidential since no definite information concerning them could be secured. One of the largest companies stated that it had no experience on physicians and radiologists using x-ray and radium and as stated above, one company at least was frank enough to admit that its statistics were insufficient and too heterogeneous to withstand analytical criticism. Most life insurance companies now have discontinued writing disability income clauses. One company that still continues to do so will not grant this to a radiologist because of an unfavorable past experience. It is interesting to note in this regard, however, that two large companies specializing in health and accident insurance write disability income contracts for radiologists at standard rates, from which one infers that their experience with their risk has not been unusual.

There are some of us who believe that the specialist in radiology, who is trained in the use and care of his equipment, is a much better life insurance risk than the physician or surgeon who owns an x-ray machine and all too frequently uses it with only a superficial knowledge of its potentialities. I have reason to believe that this opinion is also shared by at least one medical advisor who has taken the trouble to study the radiologist as an insurance risk, and this is reflected in the rate schedule of that company. On behalf of the younger generation of radiologists for whom life insurance is an important asset, I bespeak a fair consideration of their risk by insurance underwriters, particularly on the part of large companies that should be in a position to compile accurate experience tables concerning the situation.

JOHN D. CAMP, M. D.

COMMUNICATIONS

REPORT OF RADIOLOGICAL INTER-SOCIETY COMMITTEE

REMARKS BY THE EDITOR

The radiologists of this country no doubt will receive with the greatest interest and enthusiasm the report of the Radiological Inter-Society Committee.

When the different radiological societies agreed to co-operate with the American College of Radiology in the formation of an Inter-Society Committee, they helped to create a movement which is of tremendous significance to each and every radiologist of this country. This committee, with its strong personnel, will at first make a survey of the professional and economic needs of radiologists all over America, and with the aid of their competent Executive Secretary, active work soon will be under way. We can look to the future with an optimistic attitude and appreciate that organized radiology will now be able to function most efficiently.

The report of the Inter-Society Committee, here appended, is in itself sufficient justification for its creation and existence. The members of the Committee certainly have undertaken their labors with honest zeal, and we wish them to know that we are willing and ready to serve them in any capacity they may wish.

REPORT OF COMMITTEE

The following is a report of the first meeting of the Radiological Inter-Society Committee, held at the Palmer House, Chicago, Illinois, Feb. 14, 15, and 16, 1937. All of the Committee were present.

Where there is no unity of action there will be a paucity of good results, whether the objective be the conquering of a nation or the diffusion of ideas. For some years the radiologists of America have sensed the need for unified action in order that the ideals of radiology might be realized, and our specialty might take its rightful place among the subdivisions of the practice of medicine.

Activated only by the realization that someone must take the first step, the Chancellors of the American College of Radiology, at their meeting in February, 1936, named a committee of three which, it was hoped, would be acceptable to all the radiological societies and might thus fairly represent all, or nearly all, American radiologists. At its Annual Meeting in September, 1936, the American Roentgen Ray Society appointed the same committee to be its representative, and in December, 1936, the Radiological Society of North America took a like action. This movement having been endorsed in 1934 by the American Radium Society, the body of American radiologists found itself for the first time represented as a unity in its various national affairs and interests.

In November, 1936, the Julius Rosenwald Fund announced the gift of $100,000 to the American Hospital Association to be used in the study and furtherance of group hospitalization plans. Since this is a subject in which radiologists are keenly interested, the Committee at once prepared a letter for transmission to the proper committee and the officers of the American Hospital Association. The Committee expressed deep interest in the various group hospitalization plans and the liveliest desire to co-operate with the American Hospital Association in their formation and development. The letter follows:

"In order to better co-ordinate the activities of the radiological societies of America, and to more clearly and authoritatively set forth the views of American radiologists, the national societies named above have constituted a joint committee to represent them in such matters as may be considered pertinent to the purposes for which the Committee was formed.

"This Committee, representing all of the national societies of radiologists, and thus practically all radiologists of America, notes the gift by the Julius Rosenwald Fund to be used for the furtherance and betterment of voluntary hospital service plans. Like all physicians, radiologists are interested in such plans, and are anxious to co-operate fully in their organization and operation. It is undoubtedly true that the majority of American families are poorly prepared to meet the sudden demands of severe illness, and constructive steps toward enabling such demands to be met should be encouraged and supported by all physicians and by their clientele. Not only as physicians, but as citizens, we have the strongest desire to co-operate in the study and furtherance of hospitalization plans, and anticipate the day when the hospitalization of all those who may come within their scope shall be under a hospitalization service plan, and it is our strongest desire to engage in

friendly discussion with your committee concerning the exclusion of medical services and especially radiological practice from group hospitalization plans and contracts.

"Simply stated, the questions which concern us most deeply are these: Shall radiology be included in voluntary hospital insurance plans? If this question is answered in the affirmative, then shall it be included as (*a*) a hospital service, or (*b*) as a medical service so closely allied to hospital service as to be inseparable in practice, but to be paid for by indemnification? If it can be established that hospital insurance plans are not feasible without the inclusion of radiology, then the answer to our first question *must* be in the affirmative and we must pass at once to the second question and bend all our efforts toward its satisfactory solution.

"But can it be so established? It is essential that x-ray services be provided as part of hospital service, and will it be possible to devise satisfactory and workable plans for their inclusion? To these questions we are constrained to answer '*No.*' No one disputes the thesis that radiology is a medical specialty, that it is a department of the practice of medicine, and that its practitioners are and must be physicians. This being true, then it is not difficult to see that if x-ray services are included in a hospital insurance plan, surgical, obstetrical, and urological service could be included with equal propriety. When such services *are included*, we will have taken irrevocable steps toward the complete socialization of both medicine and hospitalization, and compulsory health insurance will be upon us.

"To argue (as has been done) that only the so-called 'technical services' will be included, is to state a thesis incapable of being successfully defended. No professional procedure can be divided into parts without the fatal wounding of that professional procedure. No one conversant with the problem can have any doubt but that such separation will result in two things: the ruin of a medical specialty, and increasingly poor practice within hospitals. Examples and arguments can be drawn at great length but are not necessary here. We will be glad to amplify any of these points to any degree if you deem it advisable.

"May we call your attention to the fact, known to you, of course, that the oldest and most successful of the plans now in operation, namely, the Baylor (Dallas, Tex.) and Washington, D. C., plans, do not include and never have included x-ray services? The Memphis (Tenn.) plan has lately discontinued its x-ray benefits. The Alameda County (Cal.) plan furnishes x-ray and clinical pathology as a medical service, but does so by indemnifying its subscribers for the amounts expended by them. The Intercoast Society (California) has a like provision. It would seem, therefore, that it is possible to operate these plans without the inclusion of these medical services.

"May we not ask you, then, to consider carefully and to consult further with us, before making any recommendations which may not only destroy a medical specialty, but may lead to a lowering of hospital standards, to a lessening of the value of the service received by patients, and may even result in placing numerous hospitals in the unenviable position of violating the several Medical Practice Acts.

"We will welcome inquiry or further discussion, and beg the privilege of bringing you the opinions, reactions, and joint experience of the radiologists of this country.

Sincerely yours,

(Signed) ARTHUR C. CHRISTIE, M.D.
EDWARD H. SKINNER, M.D.
LOWELL S. GOIN, M.D."

Its letter was courteously received and a conference with representatives of the American Hospital Association was arranged in Chicago, at which conference the Committee was able to exchange views and to present the viewpoint and ideals of radiologists. It is needless to say that had the Committee been unable to present itself as representative of all of the American societies and hence of all American radiologists, its efforts must have been much less effective.

Meeting with a larger group from the American Hospital Association an agreement as to the principles governing the relationship of hospitals and radiologist was reached. This agreement, which is a most happy solution to certain very vexing problems, states:

"In view of the current discussions concerning the relationship of radiologists to hospitals and because of the desirability of protecting the public, of maintaining radiological services of high efficiency, and of safeguarding the hospitals, the hospital radiologist and the interests of the non-hospital radiologist, the following basic principles are

hereby approved by the Board of Trustees of the American Hospital Association.

"1. The radiological service of the hospital shall be maintained primarily for the benefit of the sick.

"2. Every hospital radiological department should be under the direction of a competent radiologist, preferably a diplomate of the American Board of Radiology.[1] If, because of size or isolation, such arrangement be not feasible, some member of the general medical staff trained in radiology should be in charge and a consultation service arranged with a nearby radiologist.

"3. *The radiologist is entitled to recognition as a professional member of the medical staff and as head of a hospital department.*

"4. *The preservation of the unity of the hospital and its component departments and activities is an essential administrative principle. This principle can be maintained without any infringement on professional rights or professional dignity.*

"5. Inasmuch as no one basis of financial arrangement between a hospital and its radiologist would seem to be applicable or suitable in all instances, that basis should be followed which would best meet the local situation. This may be on the basis of salary, commission, or privilege rental, but in no instance should either the hospital or the radiologist exploit the other or the patient.

"6. When an arrangement is effected whereby the radiologist of the hospital pays a rental for space and service, cares for non-pay patients and in return retains all private fees collected, such contract should clearly cover the matter of depreciation of equipment, replacements and additions, should protect the radiologist against excessive non-pay work and should take into consideration the 'good will' by virtue of which a large proportion of the paying clientele is attracted.

"7. The American Hospital Association views with disapproval the proposal that the actual cost of films and associated overhead be separated from the professional charges of the radiologist or that the responsibility for this department be divorced from the hospital. While in many instances this would be a financial relief to the hospitals, it would probably result in frequent omission of the radiological consultation with a specialist in radiology, would mean less efficient radiological service with potential legal complications, and would tend to create difficulties with national and other organizations requiring supervision of the radiological work by a competent radiologist."

This Committee is happy to announce the engagement of Mr. Mac F. Cahal, of Wichita, Kansas, Executive Secretary of Sedgwick County Medical Society, as Executive Secretary. Mr. Cahal is a splendid type for the task which the Committee anticipates and has had several years of experience in this sort of work, having been for the past five years Executive Secretary to a large county medical association. Mr. Cahal will represent the interests of radiologists and of radiology at all times and in any place where his presence may be required. The Committee considers this an enormous stride toward its ultimate goal and hopes and confidently expects the financial support of the various radiological societies.

[1] "(In Canada this would read 'American Board of Radiology or an equivalent body.')"

ANNOUNCEMENTS

THE NEXT ANNUAL MEETING OF THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

Sept. 13–17, 1937, there will be held in Chicago, at the Palmer House, the Fifth International Congress of Radiology, and the first to be held outside of Europe. The Radiological Society of North America will hold its Annual Meeting during the same week as the Congress, and at the same place.

The evening programs will be assigned to the national radiological organizations of North America. Monday evening will be given to the American College of Radiology. Their program will include the convocation and dinner, the international conference, etc. This regular College function will start promptly at six o'clock and will be completed in time for the opening of the Congress at 8:30 on the same evening. Tuesday evening will be given to the American Radium Society. Their program will include the Janeway Lecture, dinner to foreign guests, special entertainment features,

etc. Wednesday evening will be given to the American Roentgen Ray Society. Their program will include the Caldwell Lecture, banquet, entertainment features, etc. Thursday evening will be given to the Radiological Society of North America. Their program will include the Carman Lecture, banquet, special entertainment features, etc.

In this way, the not inconsiderable advantages of participating in an International Congress will be easily available to all radiologists resident in the United States, Canada, and Mexico.

EXCEPTIONAL EDUCATIONAL OPPORTUNITIES AT THE FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY[1]

(At the request of A. C. Christie, M.D., of Washington, D. C., President of the Congress, this announcement is repeated, with certain additions.—*The Editor.*)

An unusual opportunity will be offered at the Fifth International Congress of Radiology, Sept. 13 to 17, 1937, Palmer House, Chicago, Illinois, for instruction in certain selected fields of radiology. The courses to be offered are as follows:

ROENTGEN THERAPY IN CANCER

Dr. Henri Coutard, Chief of Roentgen Therapy Service in the Radium Institute, Paris, France.

PROBLEMS IN ROENTGENOLOGICAL DIAGNOSIS

This is an advanced course for experienced radiologists which will deal with difficult problems of diagnosis selected from the vast material available at the Massachusetts General Hospital.

Dr. George W. Holmes, Clinical Professor of Roentgenology, Harvard University Medical School; Director of Radiological Department, Massachusetts General Hospital, Boston, Massachusetts.

Dr. Holmes will be assisted by his associates, Dr. Aubrey O. Hampton, Dr. Richard Schatzki, and Dr. Richard Dresser.

RADIATION THERAPY IN GYNECOLOGY

Dr. James Heyman, Chief of the Department of Gynecology, Radiumhemmet, Stockholm, Sweden.

THE FUNDAMENTALS OF ROENTGEN AND RADIUM THERAPY

Prof. Dr. Hermann Holthusen, Professor in the University, Chief of the Radiological Service, St. George Hospital, Hamburg, Germany.

ROENTGEN DIAGNOSIS IN GASTRO-ENTEROLOGY

Dr. B. R. Kirklin, Professor of Radiology, University of Minnesota, Graduate School of Medicine; Chief of the Department of Radiology, Mayo Clinic, Rochester, Minnesota.

Dr. Kirklin will be assisted in this course by other radiologists who are outstanding in this special field.

SPECIAL PROBLEMS OF RADIATION THERAPY RELATING PARTICULARLY TO TREATMENT OF CANCER OF THE CERVIX AND CANCER OF THE BREAST

This course is directed especially to the needs of the specialist in radiology and will be found of particular interest to radiologists located in the smaller centers of population.

Dr. Edwin A. Merritt, Clinical Professor of Radiology, Georgetown University Medical School; Chief Radiologist, Warwick Memorial Clinic and Garfield Memorial Hospital, Washington, D. C.

THE DIAGNOSIS OF BRAIN LESIONS

Dr. Merrill C. Sosman, Assistant Professor of Roentgenology, Harvard University Medical School; Chief of Radiological Service, Peter Bent Brigham Hospital, Boston, Massachusetts.

ELEMENTARY PHYSICS OF RADIATION

Dr. James L. Weatherwax, Philadelphia General Hospital, Philadelphia, Pennsylvania.

Each of the above courses will occupy four hours; that is, one hour on each day of the Congress, September 14 to 17, inclusive. The courses will be given at an hour when they

[1] Attention is directed to the addition of the course by Dr. Heyman since the announcement of these courses in the March number of RADIOLOGY.

will not conflict with other activities of the Congress, namely, eight to nine in the morning.

Each of the courses will be given in English and will be open to between fifty and one hundred members of the Congress who will register specifically for any one course. Those who have already made application for membership in the Congress may register for one of the courses by writing to the General Secretary, 2561 N. Clark Street, Chicago, Illinois. Applicants for membership in the Congress hereafter may register when they submit their applications. Registrations for the courses will be accepted in the order of their receipt at the Chicago office.

All courses will be given without extra charge to members of the Congress who register for them in the manner indicated above. It is desired that registration be made at as early a date as possible.

THE AMERICAN RADIUM SOCIETY

The American Radium Society will hold its twenty-second annual meeting at the Chelsea Hotel, Atlantic City, N. J., on Monday and Tuesday, June 7 and 8, 1937. Dr. Zoe Allison Johnston, of Pittsburgh, Pa., is the President.

The Program Committee announce the following papers:

THE PLACE OF IRRADIATION IN THE TREATMENT OF CARCINOMA OF THE UTERINE CORPUS. By LOUIS E. PHANEUF, M.D., of Boston.

THE SELECTION OF FORM OF TREATMENT IN UTERINE MYOMAS. By HENRY SCHMITZ, M.D., of Chicago.

PALLIATIVE TREATMENT OF GYNECOLOGIC CANCER. By FRANK R. SMITH, M.D., of New York City.

INTESTINAL INJURIES COMPLICATING RADIOTHERAPY OF UTERINE CANCER. By JAMES A. CORSCADEN, M.D., H. H. KASABACH, M.D., and MAURICE LENZ, M.D., of New York City.

REVIEW OF THE CASES OF CANCER OF THE URETHRA AND VULVA. By LEDA J. STACY, M.D., of White Plains, N. Y.

SOME OBSERVATIONS ON THE RESULTS OF THE TREATMENT OF BREAST CARCINOMA. By EUGENE P. PENDERGRASS, M.D., and PHILIP J. HODES, M.D., of Philadelphia.

THE TREATMENT OF BREAST CANCER. By JAMES G. SPACKMAN, M.D., of Wilmington, Del.

ARTIFICIAL MENOPAUSE IN CARCINOMA OF THE BREAST. By GRANTLEY W. TAYLOR, M.D., of Boston.

COMMENTS UPON THE USE OF RADIUM AND X-RAY IN PROSTATIC MALIGNANCIES AND HYPERTROPHY. By CURTIS F. BURNAM, M.D., of Baltimore, Md.

CANCER OF THE THYROID IN CHILDREN. By HUGH F. HARE, M.D., of Boston.

CORRELATION OF X-RAY AND GAMMA-RAY DOSAGE THROUGH IONIZATION. By L. MARINELLI, M.A., of New York City.

METHODS OF APPLYING RADIUM ELEMENT IN THE FORM OF NEEDLES AND TUBES. By GEORGE C. WILKINS, M.D., of Manchester, N. H.

A DOSE CHART FOR INTERSTITIAL RADIUM ELEMENT NEEDLES. By LAWRENCE POMEROY, M.D., of Cleveland, O.

PROTECTIVE SHIELDS IN RADIATION THERAPY OF INTRA-ORAL CANCER. By ANDREW ACKERMAN, D.D.S., of New York City.

ORGANIZATION OF TUMOR CLINIC IN GENERAL HOSPITAL WITH SMALL SUPPLY OF RADIUM. By JAMES S. GALLO, M.D., of Paterson, N. J.

MELANOMA-TYPES: PATHOLOGY AND MANAGEMENT. By GEORGE T. PACK, M.D., and FRANK E. ADAIR, M.D., of New York City.

TREATMENT OF EPITHELIOMAS OF THE NASOLABIAL FOLD. By ORVILLE MELAND, M.D., of Los Angeles, Calif.

RADIUM THERAPY OF VERNAL CONJUNCTIVITIS. By H. H. BOWING, M.D., and R. E. FRICKE, M.D., of Rochester, Minn.

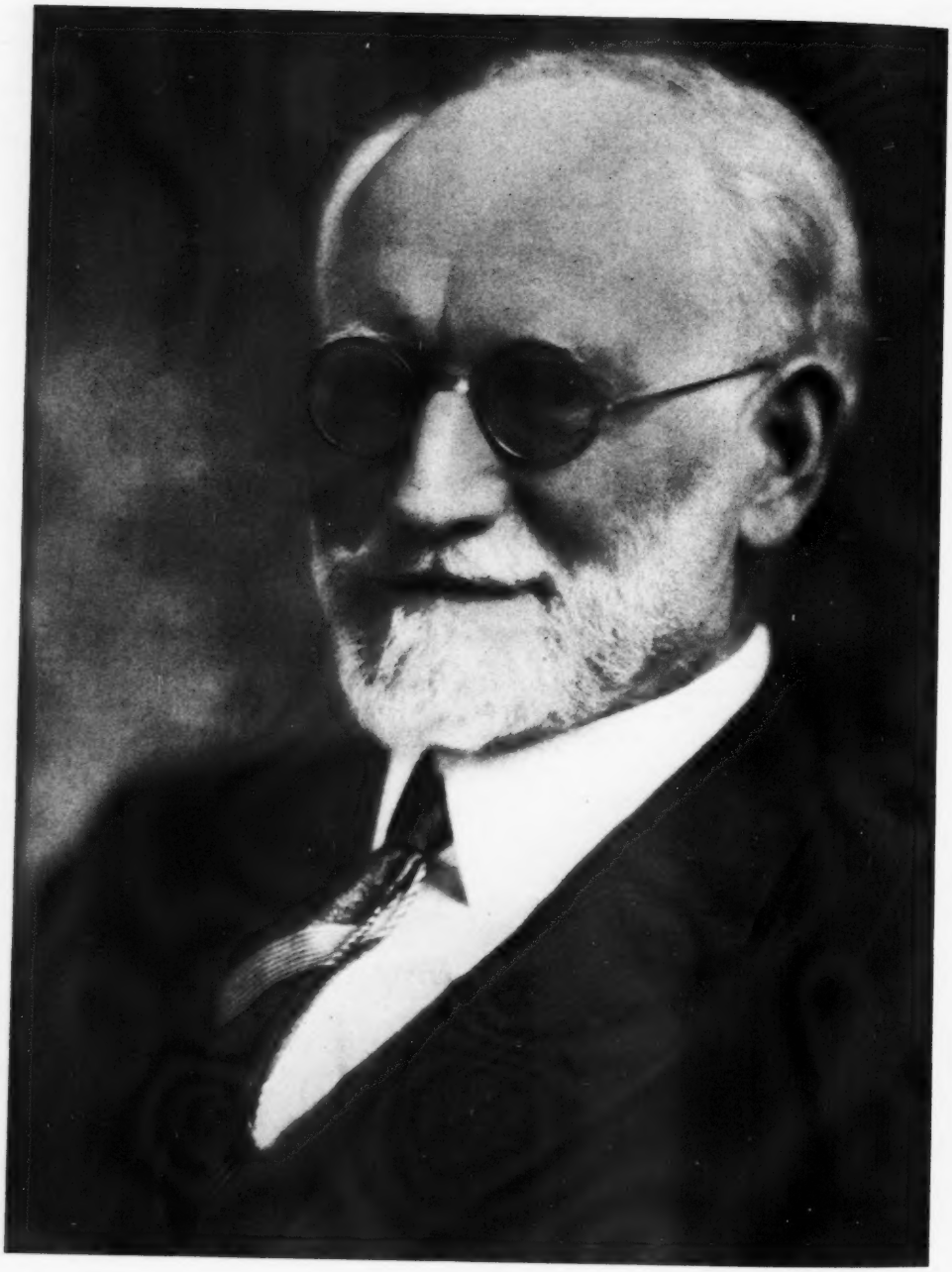
CANCER OF THE EYELIDS. By G. ALLEN ROBINSON, M.D., of New York City.

RADIUM IN THE TREATMENT OF CANCER OF FEMALE URETHRA. By IRA I. KAPLAN, M.D., New York City.

THERAPEUTIC USES OF OESTRIN. By CHARLES F. GESCHICKTER, M.D., Baltimore, Md.

The annual banquet will be held on Monday night, June 7, at the Hotel Chelsea. The President, Dr. Zoe Allison Johnston, will give a talk upon Madame Curie. Mrs. Edith H. Quimby, M.A., Memorial Hospital, New York City, will discuss Radiological Physics.

THE PROGRAM COMMITTEE
E. H. SKINNER, M.D., *Chairman*
HAYES E. MARTIN, M.D.
LYELL C. KINNEY, M.D.



The late AUGUSTUS W. CRANE, M.D.

IN MEMORIAM

AUGUSTUS WARREN CRANE

1868–1937

Radiology has suffered another great loss. Dr. Crane has gone to his reward. And surely great must be the eternal recompense for a life of such outstanding service to his fellowmen. Few men in radiology have so importantly and favorably influenced a specialty. Added to the international distinction he won in his professional endeavor, Dr. Crane won a place in the highest esteem of his fellow-citizens for the personal characteristics which made him an extraordinary and kindly figure in his home community, and which endeared him without exception to all with whom he came in contact.

Although he had already made a promising start in the general and laboratory practice of medicine, having published several researches relating to the physiology of the blood, the publication of Roentgen's discovery so fascinated young Crane that he devoted himself with scholarly zeal to the study of the roentgen rays, their production, control, and application to the science of medical diagnosis and therapy.

Within three months of Roentgen's first publication Dr. Crane had installed his first x-ray machine—a 12-inch coil operated by a homemade battery and mechanical break (March, 1897). His studies on the matter of interrupters, which, before the day of the interrupterless machine invented by H. C. Snook, by their eccentricities rivaled the gas x-ray tube in the botheration they caused the radiologist, were crystallized in a lecture at the University of Michigan in March, 1901, describing a method of operating a coil from an alternating circuit by means of an electrolytic interrupter. This lecture led to the general use of the Wehnelt interrupter for running x-ray coils on alternating current.

Dr. Crane's earliest and perhaps most notable contribution to the literature of radiology was a paper, illustrated by x-ray plates, read before the Kalamazoo Academy of Medicine on Sept. 27, 1898, entitled "The Roentgen Ray in Diseases of the Lungs." Under the title "Skiascopy of the Respiratory Organs," this paper was published in the "Philadelphia Medical Journal" of March, 1899. It was received so favorably in England that several medical authors incorporated large parts of it in English text-books. It was real pioneer work, not sufficiently appreciated by many American workers. This essay was reprinted in the "American Journal of Roentgenology," 1916, Vol. 3, new series, p. 419, for the benefit of students of roentgenology who had not known of Dr. Crane's valuable early contribution. Readers of this page not familiar with this early pioneering of Dr. Crane will find it instructive to review what was so early accomplished by one man through the sheer force of his own initiative and his brilliant intellect. In this paper Crane really anticipated most of the radiological developments in the study of the chest during the next two decades.

In gastro-intestinal work Crane merits a pioneer's acclaim. His first plates of the stomach and colon were made on Dec. 8, 1905. In March of the following year he read a paper, illustrated with numerous plates, on "The Position and Shape of the Stomach and Intestines during Life." In June, 1907, there followed a paper on "Gastroptosis," and on Dec. 10, 1907, a paper on "Gastric Ulcer." This was also the title of his first paper before the American Roentgen Ray Society, in 1908. The following year he read before the American Medical Association on "X-ray Evidence in Gastric Cancer."

Dr. Crane's early training and interest in the study of the blood was continued in a paper read in 1907 on "Specific Immunity of X-ray Therapeutics," which called attention to the effect of the x-ray in producing an immunity parallel to that produced by vaccines.

In 1915 Dr. Crane read a paper before the American Medical Association entitled "Roentgenocardiograms," the term "roentgenocardiogram" being coined by Dr. Crane to conform with the term "electrocardiogram." This paper was pioneer work in a line of investigation now being brought to the fore under the name of "roentgenkymography."

Augustus Warren Crane was born in Adrian, Michigan, on Nov. 13, 1868, the son of Nathan Seeley and Julia Etta Chaffee Crane. After attending the Adrian High School and the literary department of the University of Michigan, he graduated from the medical department in 1894 as valedictorian of his class. He immediately afterward established himself in Kalamazoo, Michigan, in the general practice of medicine and surgery. Early attention was given to laboratory work, and in 1895 he was appointed city bacteriologist, the

first in the State of Michigan. His early medical papers before the Kalamazoo Academy of Medicine dealt with laboratory methods of diagnosis, pathology, and especially with various phases of blood examinations. In 1898 he made an effort to discover the biological meaning of the different blood cells by a study of the blood of mammals, reptiles, fishes, birds, worms, crustaceans, and insects, in the course of which he visited many scientific museums for the procurement of blood specimens. These researches were presented in a paper before the Michigan State Medical Society under the title, "Missing Links in the Clinical Examination of the Blood."

Until 1906 Dr. Crane carried on a large general practice and did considerable surgery, while continuing his radiological pioneering, but after that date he confined his practice to internal medicine, and after 1915 his work was restricted to diagnosis and consultation practice, in which roentgenology became his chief interest.

Crane maintained that the correlation of clinical data with the roentgen findings is the legitimate province of the clinical roentgenologist, and constitutes the main reason for the medical education of the roentgenologist. This is the reason, he maintained, why roentgenology is entitled to the recognition of a full professorship co-equal to the chair of medicine or surgery; why entitled to a separate section in the American Medical Association; why its worthy followers should be invested with all the privileges of professional consultation without discrimination from other specialties. Crane insisted that such a practice, while exclusively diagnostic except for roentgen therapy, is not exclusively roentgenological. He called it clinical roentgenology.

And so he may be considered to represent the ideal in a roentgenological specialist, a physician who all along maintained his standing and efficiency as a clinical diagnostician and practitioner of therapeutic radiology while developing superior skill in the application of the roentgen rays to medical problems.

Many honors have fallen to Dr. Crane. Early in his career he was made a member of the British Roentgen Society, 1899; president of the American Roentgen Ray Society in 1916; Caldwell Lecturer in 1932; acting editor of the "American Journal of Roentgenology" in 1917–1918; recipient of the gold medal of the Radiological Society of North America in 1921 for his achievements in the science of radiology; recipient of the honorary degree of Master of Arts from his alma mater in 1932.

At the time of his honorary degree from the University of Michigan, attention was called to the studied care which marked the written contributions of this pioneer investigator. Gifted with a facility of speech that is rarely the lot even of those whose vocation is to speak from the public platform, he was always able to interest and hold the attention of an audience. Possessed of a scientific imagination and a mastery in the use of metaphor, he was able to add interest to any subject on which he essayed to write. His papers were characterized by simplicity and clearness as well as by harmony in his choice of words. A Michigan editor recorded that as a phrase artist he was able to give pen to such expressions (referring to that part of the anatomy immediately above the diaphragm) as the "costal grill," "the thoracic cage," "the chest—that one cavity of the body ready-made for roentgen examination." He wrote of one radiologist as having "spent the best years of his life on a medical frontier." He wrote of roentgenology: "The discovery was unexampled in dramatic surprise and promise."... "The miracle of shadows cast by invisible light gave increasing power and precision to diagnosis."... "It is the part of the pioneer to brave dangers and hardships. In this far region of the spectrum were lurking unknown dangers, unseen, insidious, deadly."

One of his latest contributions, "The Research Trail of the X-ray," presented at the American Congress of Radiology at Chicago in 1933, revealed the breadth of his investigations. This paper is a classic in radiological and scientific literature, and should be treasured by all whose interests center in radiology.

Dr. Crane's home life was a happy one. His wife was a distinguished minister of the Gospel and an important figure in state and national life. She preceded him in death by nearly two years. Surviving are two children, a daughter living at home, and a son, Warren Bartlett Crane, who will shortly graduate in medicine from the University of Chicago. Death came to Dr. Crane suddenly on the morning of Feb. 20, 1937, at the age of 68.*

JAMES T. CASE, M.D.

* The writer has borrowed freely from others in preparing this notice.—J. T. C.

ABSTRACTS OF CURRENT LITERATURE

CONTENTS BY SUBJECT

Abscess (Pulmonary) 509
Actinomycosis 509
Animal Experimentation 509
Apparatus 510
Arteriography 510
Arthritis 510
Biologic Effects of Radiation 511
The Bladder 511
Blood Changes 512
Bone Diseases 512
Bone Diseases (Therapy) 514
Breast Cancer 514
Calcification 515
Cancer (Diagnosis) 515
Cancer (Therapy) 515
The Cecum 518
The Colon 518
Contrast Media 518
The Cranium 519
Dermoid Cyst 519
Diabetes 519
Dosage 519
Encephalography 520

THE FOLLOWING ABSTRACTORS HAVE CONTRIBUTED TO THIS ISSUE

J. N. Ané, M.D., of New Orleans, La.
S. M. Atkins, M.D., of Waterbury, Conn.
G. E. Burch, M.D., of New Orleans, La.
Joseph Dauksys, M.D., of Excelsior Springs, Mo.
J. E. Habbe, M.D., of Milwaukee, Wisc.
Hans W. Hefke, M.D., of Milwaukee, Wisc.
Hans A. Jarre, M.D., of Detroit, Mich.
E. T. Leddy, M.D., of Rochester, Minn.
Ernst A. Pohle, M.D., Ph.D., of Madison, Wisc.
W. A. Sodeman, M.D., of New Orleans, La.
William R. Stecher, M.D., of Easton, Pa.
Charles G. Sutherland, M.B. (Tor.), of Rochester, Minn.

CONTENTS OF ABSTRACTS IN THIS ISSUE LISTED ALPHABETICALLY BY AUTHORS

Albee, Fred. H. The Treatment of Primary Malignant Changes of the Bone by Radical Resection with Bone Graft Replacement ... 514
Balser, Ben H., *with* Bendick, A. J., jt. auth. ... 520
Battigelli, G. Generalized Tuberculous Lymphadenopathy ... 515
Bendick, A. J., and Balser, Ben H. Cerebral Roentgenoscopy as an Aid in Pneumoventriculography and Encephalography ... 520
Beutel, A. Ossification of the Stylohyoid Ligament ... 515
Binks, W., *with* Kaye, G. W. C., jt. auth. ... 520
Bird, Clarence E. The Treatment of Large Pulmonary Abscesses ... 509
Bishop, Paul A. Bone Changes in Chronic Fluorine Intoxication: A Roentgenographic Study ... 513
Böhler, Lorenz. The Causes of Traumatic Myositis Ossificans Following Dislocations of the Elbow ... 512
Bunting, C. H., *with* Pohle, E. A., jt. auth. ... 509
Chaoul, H. The Treatment of Rectal Carcinoma by Surgical Freeing and Exposure to "Close" Roentgen Therapy ... 517
Constantino, Demetrio, *with* Talia, Ferdinando, jt. auth. ... 518
Coutard, H. Roentgen Therapy of Carcinoma and Periodicity of the Epithelial Changes ... 517
Downs, Elwood Emerson. Lung Changes Subsequent to Irradiation in Cancer of the Breast ... 514
Ebbehoj, E. Experiments Regarding the Treatment of Skin Cancer with Very Soft Roentgen Rays ... 516
Engels, H. Results of Radiation Therapy of Carcinoma of the Bronchus ... 517
Ferguson, R. S. Treatment of Cancer of the Bladder by Divided Doses of Roentgen Rays at Long Distances ... 511
Ferroux, K., Regaud, C., and Samssonow, N. The Increase of Radioresistance Following Repeated Exposure to Small Doses of Roentgen Rays ... 509
Frankel, S. R., and Neumann, I. M. The Biologic Basis of the Newest Methods of Roentgen Therapy ... 509
Fuchs, G. The Influence of Electromagnetic Waves on the Freund-Kaminer Cancer Reaction ... 517
Ganz, E. The Fate of the Patients with Carcinoma of the Breast Treated at the Roentgen Institute in Zurich during 1920–1932 ... 514
Gil y Gil, C. Roentgen Therapy of Malignant Papilloma and Carcinoma of the Bladder ... 517
Glasser, Otto, and Rovner, Leopold. Dosimetry in Radiation Therapy. I.—Gamma-ray Measurements in Roentgens ... 520
Goedel, R. Contribution to the Symptomatology of *Ostitis cendensans ossis ilei* ... 513
Goldstein, D. W. Fatal Iododerma Following Injection of Iodized Oil for Pulmonary Diagnosis ... 518
Gomez, E. T., *with* Turner, C. W., jt. auth. ... 509
Graham, Roscoe R. Diverticulitis of the Sigmoid Colon ... 518
Hill, Donald F., *with* Holbrook, W. Paul, jt. auth. ... 510
Hinton, J. William, and Trubek, Max. The Transformation of Gastric Ulcer into Gastric Carcinoma ... 515
Holbrook, W. Paul, and Hill, Donald F. Treatment of Atrophic Arthritis ... 510
Holthusen, H. Practical Experiences with the Reliability of the Indirect Dosimetry ... 520
Hutton, James H. Hypertension and Diabetes: Their Treatment by Radiotherapy ... 519
Jaffé, R. H. The Bone Marrow ... 512

KARTAGENER, M. "Le Pied en Lorgnette" in Chronic Polyarthritis..... 511
KAYE, G. W. C., and BINKS, W. Dosage of Gamma Rays by Ionization Measurements. 520
KUHNS, J. G., *with* MORRISON, S. L., jt. auth.... 511
LACASSAGNE, A. Studies of the Radiosensitivity of the Corpus Luteum and of the Uterine Membrane by Means of an Artificially Produced Deciduoma in the Rabbit..... 510
LIECHTI, A., and MULLER, J. H. The Summation of the Effect of Various Types of Rays on the Biologic Object..... 511
MCKENNEY, DESCUM C. Multiple Polyposis of Colon: Familial Factor and Malignant Tendency..... 518
MARAGLIANO, V. A Method for the Concentration of Roentgen Rays in the Depth..... 520
MARBURY, WILLIAM B., and PECKHAM, HENRY L. Brodie's Abscess of Radius, Due to Typhoid..... 512
MARTIN-CRESPO, J. Roentgen Therapy of Actinomycosis..... 509
MARTIN, H. E. Variations in the Technic and Biologic Effects of Fractionated Doses of X-radiation..... 519
MAYER, CHARLES. Surgical Treatment of Organic Obliteration of the Lower Extremities..... 510
MONTEFUSCO, CORRADO. Roentgen Irradiation through the Temples for Diabetes Mellitus. 519
MORRISON, S. L., and KUHNS, J. G. Roentgenological Changes in Chronic Arthritis: A Correlation with Clinical Observation for Long Periods of Time..... 511
MÜLLER, J. H., *with* LIECHTI, A., jt. auth..... 511
NEUMANN, I. M., *with* FRANKEL, S. R., jt. auth.. 509
PACK, GEORGE T. The Principles Governing the Radiation Therapy of Cancer..... 515
PÄTZOLD, J. Special Problems in Ultra-short Wave Therapy..... 510
PECKHAM, HENRY L., *with* MARBURY, WILLIAM B., jt. auth..... 512
PHEMISTER, DALLAS B., STEEN, WILLIAM B., and VOLDERAUER, JOHN C. A Roentgenologic Criterion of Dermoid Cyst..... 519
PITTS, HERMAN C., and WATERMAN, GEORGE B. The Treatment of Cancer of the Cervix Uteri at the Rhode Island Hospital..... 516
POHLE, E. A., and BUNTING, C. H. Histological Studies of the Spleen in Rats Following Exposure to Graded Doses of Roentgen Rays. 509
PUGNO-VANONI, E. An Automatic Roentgen Therapy Apparatus for Ultra-hard Rays... 510
REGAUD, C., *with* FERROUX, K., jt. auth..... 509
REYNOLDS, R. The Use of Roentgen Rays of Moderate Wave Length in the Treatment of Certain Diseases..... 519
RICHARDS, G. E. The Radiological Treatment of Cancer, 1929–1935: IV.—Carcinoma of the Lips..... 516
ROVNER, LEOPOLD, *with* GLASSER, OTTO, jt. auth. 520
RUSCH, DR., *with* SCHUMACHER, P. H., jt. auth... 512
SAMSSONOW, N., *with* FERROUX, K., jt. auth..... 509
SCHLIEPHAKE, E. Specific Effect of Ultra-short Wave Field..... 511
SCHUMACHER, P. H., and DR. RUSCH. The Influence of Roentgen Rays on the Cholesterol Content of Blood and Serum in Women with Carcinoma or Sarcoma..... 512
SMITH, E. GERARD. Sterilization in Carcinoma of the Breast..... 515
STEEN, WILLIAM B., *with* PHEMISTER, DALLAS B., jt. auth..... 519
SUTHERLAND, CHARLES G. Lesions Involving the Cranium and its Contents..... 519
TALIA, FERDINANDO. The Practical Value of Double Exposure of Films..... 510
TALIA, FERDINANDO, and CONSTANTINO, DEMETRIO. Inversion of the Cecum: Its Relationship to Appendicitis..... 518
THOMPSON, J. W. Secondary Resections in Recurring Carcinoma of the Colon..... 518
TIMOFÉEFF-RESSOVSKY, N. W., *with* WILHELMY, E., jt. auth..... 511
TRUBEK, MAX, *with* HINTON, J. WILLIAM, jt. auth. 515
TURNER, C. W., and GOMEZ, E. T. The Radiosensitivity of the Cells of the Mammary Gland..... 509
VOLDERAUER, JOHN C., *with* PHEMISTER, DALLAS B., jt. auth..... 519
WATERMAN, GEORGE B., *with* PITTS, HERMAN C., jt. auth..... 516
WEBER, W. Etiology and Pathogenesis of Solitary Bone Cysts..... 513
WEBSTER, J. H. D. Roentgen Therapy of Primary Carcinoma of the Breast and the Doses Used Expressed in International Roentgens. 514
WILHELMY, E., TIMOFÉEFF-RESSOVSKY, N. W., and ZIMMER, K. G. Genetic Experiments with Very Soft Roentgen Rays on *Drosophila melanogaster*..... 511
ZIMMER, K. G., *with* WILHELMY, E., jt. auth..... 511

ABSCESS (PULMONARY)

The Treatment of Large Pulmonary Abscesses. Clarence E. Bird. Jour. Am. Med. Assn., Oct. 17, 1936, **107,** 1288–1292.

In his series 65.7 per cent could not be ascribed to anything more definite than a "cold," "influenza," or "pneumonia." Of the others, 28.6 per cent followed operations, infected traumatic wounds, or other extrapulmonary infections.

The author stresses some 14 points that he considers to be of the greatest importance in relation to the surgical treatment of pulmonary abscess. Emphasis is placed on long continued, dependent drainage, under hospital care, until the cavity of the abscess is entirely obliterated.

CHARLES G. SUTHERLAND, M.B. (Tor.).

ACTINOMYCOSIS

Roentgen Therapy of Actinomycosis. J. Martin-Crespo. Strahlentherapie, 1936, **56,** 650.

In the author's opinion roentgen therapy is the method of choice in actinomycosis involving the face. He does not consider the internal administration of iodine as an essential part of the treatment. Technic: $H.V.L._{Cu}$ 0.98 mm., two convergent fields directed to the lesion, 330 r each. This may be repeated if necessary after three weeks. While good results were obtained in the majority of the cases, the lock-jaw in patients with processes of long standing was improved very little. Surgery should be limited to the draining of pus.

ERNST A. POHLE, M.D., Ph.D.

ANIMAL EXPERIMENTATION

Histological Studies of the Spleen in Rats Following Exposure to Graded Doses of Roentgen Rays. E. A. Pohle and C. H. Bunting. Strahlentherapie, 1936, **57,** 121.

The authors exposed the spleens of 181 rats to x-rays (100 kv., 2.0 mm. Al, λ eff. = 0.34 Å.). The doses varied from 5 to 5,000 r (measured in air) at intervals of from 0 minutes to 30 days. The animals were killed and the spleens prepared for histologic examination. The chief effects of roentgen rays upon the spleen were noted in the fixed and circulating blood cells in the organ; the lymphocytes appeared to be the most susceptible. Any measurable dose of roentgen rays, *i.e.*, from 5 r up, produced injuries which are demonstrable microscopically. The earliest interval in which decisive lesions were found was 30 minutes. The histologic changes are well marked three hours after exposure. They are more marked at six hours, and at 12 hours little evidence of injury is noted. At the 24-hour interval practically all cell detritus has been removed from the Malpighian corpuscles. Spleens of animals treated with 100 r appear entirely normal when examined at 14- and 30-day intervals after the exposure. With doses of 1,000 r, 2,500 r, and 5,000 r, recovery of the Malpighian corpuscles appears complete in three days. In only one spleen (1,000 r) was fibrosis noted at the 30-day interval. No statement can be made as to late injuries, since the longest interval between exposure and microscopic study was 30 days.

ERNST A. POHLE, M.D., Ph.D.

The Radiosensitivity of the Cells of the Mammary Gland. [illegible]. W. Turner and E. T. Gomez. Am. Jour. Roentgenol. and Rad. Ther., July, 1936, **36,** 79–93.

Experimenting with rabbits, the following conclusions were drawn: The rudimentary ducts of the breast of the young required considerable irradiation to depress the growth entirely, but less when they were first stimulated to growth by the estrogenic hormone.

When the duct system of the mature virgin rabbit was complete, considerable irradiation was required to prevent lobule-alveolar growth; during pregnancy or pseudo-pregnancy, the cells are very sensitive, and once effected, remain so permanently.

S. M. ATKINS, M.D.

The Biologic Basis of the Newest Methods of Roentgen Therapy. S. R. Frankel and I. M. Neumann. Strahlentherapie, 1936, **57,** 195.

The authors studied the oxidation and glycolysis in normal tissue under the influence of roentgen rays in rabbits. Sixty-four animals were used divided into five series; one series served as control. The spleens of the animals were irradiated with single doses of from 600 to 1,800 r, with fractional doses amounting to a total of 1,800 r in 12 days and the protracted fractional dose method with the same total dose (180 kv., 0.5 mm. Cu + 1 mm. Al, 23 cm. F.S.D.). The animals were killed by means of electric current and the tissues (taken from liver, spleen, and kidneys) examined by the method of Warburg. Definite changes in the metabolism of these tissues as compared with the normal controls were detected. Histologic examination of the organs showed no changes in liver and kidneys, while in the spleens of several animals, including the control series, there was hemosiderin and some sclerosis. The relationship between the method of application and the type of changes observed is briefly discussed.

ERNST A. POHLE, M.D., Ph.D.

The Increase of Radioresistance Following Repeated Exposure to Small Doses of Roentgen Rays. K. Ferroux, C. Regaud, and N. Samssonow. Strahlentherapie, 1936, **57,** 12.

Clinical observations seem to indicate that the radiosensitivity of previously irradiated tissue is lowered.

The authors studied this problem experimentally by exposing the testicles of rats to roentgen rays. Technic: 180 kv., 5 ma., 30 cm. F.S.D., 8 mm. Al + 15 mm. wood, 75 r in 1 minute, 15 seconds; the sterilization dose for the rat testicle amounted to approximately 1,180 r. For a period of 10 months, 75 r were applied every month; then the full sterilization dose was given. Control rats received only the full sterilization dose. Within four months after its application no sperm cells could be found in the testicle; in only one animal out of seven a few were left. In the animals which had received the small doses over the ten-month period before the application of the full sterilization dose, the destructive effect was much less. The testicles of four out of five animals showed sperm cells in all stages of development; some looked entirely normal. It is concluded from these experiments that the exposure to the ten fractional doses reduced the radiosensitivity of the testicle. This is apparently the same phenomenon which has been observed in the treatment of malignant tumors.

ERNST A. POHLE, M.D., Ph.D.

Studies of the Radiosensitivity of the Corpus Luteum and of the Uterine Membrane by Means of an Artificially Produced Deciduoma in the Rabbit. A. Lacassagne. Strahlentherapie, 1936, **56,** 621.

The ovaries and uterus of a number of small rabbits were exposed to roentgen rays (180 kv., 0.5 mm. Cu + 3.0 mm. Al, 5 ma., 35 cm. F.S.D.). The doses varied between 500 and 1,800 r; the animals were killed 12 days after exposure. It appeared that irradiation of the ovaries with large doses (1,300–1,800 r), given before the follicle rupture occurs, does not prevent the formation of the corpus luteum. The latter regresses early, which leads to a shrinking process in the uterine membrane. A less intense exposure (500–1,300 r) does not inhibit the normal development of the corpus luteum. The author concludes from his experiments that the uterine membrane is quite radioresistant.

ERNST A. POHLE, M.D., Ph.D.

APPARATUS

The Practical Value of Double Exposure of Films. Ferdinando Talia. Archivio di Radiologia, 1935, **11,** 365–378.

Talia illustrates the value that double exposures may have in x-ray examinations. In this technic all the factors of usual radiography are kept constant except the time of the first exposure which is reduced to one-half or one-third. The method may be of greater diagnostic help than the usual radiograph in studies of the bone or the ligaments of the abdominal vicera, the relationships of the various organs, the diagnosis of the site or the extent of some periviceral process, the study of the mobility of foreign bodies, especially in the orbit and the localization of the depth of foreign bodies.

E. T. LEDDY, M.D.

An Automatic Roentgen Therapy Apparatus for Ultra-hard Rays. E. Pugno-Vanoni. Strahlentherapie, 1936, **57,** 338.

The author describes an apparatus for the production of ultra-hard roentgen rays to be used in therapy. It can be operated at 800 kv., although the tube at this time tolerates only 600 kv. It is constructed in such a manner that technicians may operate it and consequently it does not require the constant supervison of a physicist. A diagram of the circuit is appended.

ERNST A. POHLE, M.D., Ph.D.

Special Problems in Ultra-short Wave Therapy. J. Pätzold. Strahlentherapie, 1936, **57,** 627.

The author pleads for more detailed data in publications dealing with short wave therapy. He believes that the type of apparatus, the wave length, the size of the electrodes and distance from the skin, the length of the cables, and the position of the patient should be stated. For determinations of the temperature, he recommends a quartz benzol thermometer.

ERNST A. POHLE, M.D., Ph.D.

ARTERIOGRAPHY

Surgical Treatment of Organic Obliteration of the Lower Extremities. Charles Mayer. Bruxelles-méd., May 17, 1936, **16,** 1090–1098.

While discussing the treatment of organic arterial obstruction of the lower extremities, by resection of the second and third lumbar ganglia in seven cases, the author details a radiographic differential diagnosis following injection of uroselectan into the femoral artery.

The author observes that following arteriography, in 36.2 per cent of 120 persons, there was distinct amelioration of the pain and in some cases, ability to return to work.

JOSEPH DAUKSYS, M.D.

ARTHRITIS

Treatment of Atrophic Arthritis. W. Paul Holbrook and Donald F. Hill. Jour. Am. Med. Assn., July 4, 1936, **107,** 34–38.

Atrophic arthritis is a constitutional disease which manifests itself as a profound systemic disturbance and by a chronic deforming polyarthritis. It is a disease without a known single specific etiologic agent and likewise there is no single specific cure.

The authors review the therapeutic procedures from two angles, the constitutional and the local. Diet should be arranged according to the patient's individual needs. The various problems of bowel management, removal of foci of infection, the use of vaccines, fever therapy, foreign protein injections, blood transfusions, and various medicines are discussed. General physical therapy can be carried out successfully only under the direction of a thoroughly trained personnel. The prevention and correction of deformity must anticipate the possibility of residual deformity in involved joints and avoid it. With proper and continuous care from the onset of the disease, there should be few deformities requiring special treatment.

CHARLES G. SUTHERLAND, M.B. (Tor.).

Roentgenological Changes in Chronic Arthritis: A Correlation with Clinical Observation for Long Periods of Time. S. L. Morrison and J. G. Kuhns. Am. Jour. Roentgenol. and Rad. Ther., May, 1936, **35,** 645–655.

This study was made to determine what changes would be found in chronic arthritis in serial roentgenograms taken over long periods of time, and whether or not the clinical and roentgenologic changes paralleled each other. It was found that the roentgenologic changes are extremely varied at different ages of the individual, and at different stages of the disease, and a diagnosis of the type and severity should be made only after a review of all the data obtained from a study of the patient.

Roentgenograms determine the location, extent, and progression of the disease, yet extensive changes may be compatible with good function. The morbid changes observed in roentgenograms usually progressed for a long time, no matter what the clinical course or treatment, and became stationary long after clinical quiescence.

Recalcification occurred but rarely; fusion of the sacro-iliac joints was common. In older individuals the changes are more rapid. Both atrophic and hypertrophic manifestations were frequently superimposed as age increased.

S. M. ATKINS, M.D.

"Le Pied en Lorgnette" in Chronic Polyarthritis. M. Kartagener. Schweiz. med. Wchnschr., May 16, 1936, **66,** 479–481.

The condition under consideration is that of massive resorption of the bone of the phalanges, the fingers then becoming too short for the superfluous skin which wrinkles and telescopes upon itself. This is a rare condition, particularly when occurring in the toes. In the author's case, the accompanying roentgenograms delineate the profound generalized osteoporosis of the involved digits and distal ends of metatarsals. The cause was unquestionably a resultant of polyarthritis.

WILLIAM R. STECHER, M.D.

BIOLOGIC EFFECTS OF RADIATION

The Summation of the Effect of Various Types of Rays on the Biologic Object. A. Liechti and J. H. Müller. Strahlentherapie, 1936, **57,** 284.

The authors studied the summation of the effect of x-rays, Grenz rays, and ultra-violet rays on *Ascaris* eggs and bacteria. Roentgen rays produced at 160 kv. and filtered through 3 mm. Al were used (H.V.L.$_{Cu}$ 0.35 mm., 60 r per minute at 30 cm. for the experiments on Ascaris and 100 r per minute at 23 cm. for the bacteria). Technic for Grenz rays: 12 kv., 10 ma., 11.5 cm. distance, 215 r per minute. The ultra-violet rays came from a quartz mercury vapor lamp. It was calibrated in arbitrary units by means of a photoelectric cell. From the experiments the authors deduce that there is incomplete summation of the effects of roentgen, Grenz rays, and ultra-violet rays. They assume, therefore, that the mechanism of effect of ultra-violet rays is quite different from that of roentgen and Grenz rays.

ERNST A. POHLE, M.D., Ph.D.

Genetic Experiments with Very Soft Roentgen Ray on *Drosophila melanogaster*. E. Wilhelmy, N. W. Timoféeff-Ressovsky, and K. G. Zimmer. Strahlentherapie, 1936, **57,** 521.

After a brief description of the apparatus used by the authors to produce very soft roentgen rays at from 2 to 7 kv., they report the results of their experiments on the fruit fly. If the plasma is irradiated alone (without the chromosomes), no mutations are produced. The same holds true if the soma but not the gametes are irradiated. No difference in the rate of mutation could be noticed for radiation applied at 270 r/min. and 2,700 r/min. No effect of the wave length could be noticed for equal doses of radiation produced at 6.2 kv. and harder radiation.

ERNST A. POHLE, M.D., Ph.D.

Specific Effect of Ultra-short Wave Field. E. Schliephake. Strahlentherapie, 1936, **57,** 151.

The author defines as specific effect of ultra-short waves such changes as cannot be produced by any other therapeutic agent in the same manner. Experimental and clinical observations are quoted which indicate that there is a definite relation between wave length and biologic effect.

ERNST A. POHLE, M.D., Ph.D.

THE BLADDER

Treatment of Cancer of the Bladder by Divided Doses of Roentgen Rays at Long Distances. R. S. Ferguson. Am. Jour. Roentgenol. and Rad. Ther., July, 1936, **36,** 73–78.

This is a report of a series of 48 cases, 36 of which

were verified by biopsy and observed cystoscopically. The first of these patients was treated in June, 1935, and thus the follow-up is one year for the earliest cases.

The rate of primary regression exceeds that observed in any other form of irradiation. Twenty cases showed complete regression, with appearance of a new tumor in but one.

The roentgen prescription was: 200 kv., Thoraeus filter, 100 cm. distance, 100 r daily to each of two opposite portals till from 3,000 to 4,000 r had been given through four fields.

S. M. Atkins, M.D.

BLOOD CHANGES

The Influence of Roentgen Rays on the Cholesterol Content of Blood and Serum in Women with Carcinoma or Sarcoma. P. H. Schumacher and Dr. Rusch. Strahlentherapie, 1936, **57,** 532.

The authors determined the cholesterol content of blood and serum in 40 women, 25 of whom were suffering from carcinoma or sarcoma. Following roentgen irradiation no definite fluctuations of the cholesterol count in either blood or serum could be noted. There was no relation in this series between cholesterol content and roentgen sickness. No difference could be detected in the cholesterol fluctuations between patients with and without malignant disease. In all cases the cholesterol content of the blood seemed to be slightly higher than that in serum. The authors cannot recommend, therefore, application of cholesterol by mouth as a preventive of x-ray sickness.

Ernst A. Pohle, M.D., Ph.D.

BONE DISEASES

Brodie's Abscess of Radius, Due to Typhoid. William B. Marbury and Henry L. Peckham. Jour. Am. Med. Assn., Oct. 17, 1936, **107,** 1284–1286.

Typhoid of the bones is one of the unusual types of inflammatory bone disease. Osteomyelitis complicating typhoid is not at all common. The ribs are the most common bones involved, the tibia second, and the spine third.

In bone disease following typhoid, the symptoms usually come on so ate that the typhoid bacillus is seldom considered as the etiologic factor; the interval may be from five to fourteen years. The authors report a case in which the interval was ten years.

Roentgenographically, the lesion was a Brodie's abscess, "a bone cavity filled with serum or pus, lined by a fibrous membrane with surrounding sclerosed bone and a tendency toward obliteration of the adjacent medullary cavity."

Surgical intervention revealed pus which on culture proved to be the result of typhoid bacilli.

The prognosis is good if adequate drainage is supplied.

Charles G. Sutherland, M.B. (Tor.).

The Bone Marrow, R. H. Jaffé. Jour. Am. Med. Assn., July 11, 1936, **107,** 124–129.

The importance of the examination of the bone marrow *in vivo* becomes evident if one considers the fact that the circulating blood does not always reflect the condition of the bone marrow. Great differences exist sometimes between the cellular content of the blood and that of the bone marrow, which may be the source of diagnostic errors. A brief discussion of the normal bone marrow is presented, with the changes that are observed in some of the important disturbances of blood formation. These include the anemias, polycythemia vera, agranulocytosis, the leukemias, thrombocytopenic purpura, hemophilia, tumors of the bone marrow, and bone marrow biopsy.

Charles G. Sutherland, M.B. (Tor.).

The Causes of Traumatic Myositis Ossificans Following Dislocations of the Elbow. Lorenz Böhler. Fortschr. a. d. Geb. d. Röntgenstrahlen, June, 1936, **53,** 823–840.

This is an important paper by this well-known orthopedic surgeon. It reviews 124 cases of injury to the elbow, treated and re-examined repeatedly during the last ten years. Of these cases, 65 were recent injuries which came for reduction and treatment to Dr. Böhler's clinic. An additional 24 were referred for treatment immediately after reduction, while 35 cases were referred after reduction and treatment for examination and medical testimony concerning their disability. For classification these patients were grouped as follows: (*A*) Pure and simple dislocations; (*B*) Dislocations with detachment of bony segments; (*C*) Combinations of fractures and dislocations; (*D*) Pathologic dislocations.

The paper then analyzes in detail 29 cases of Group A: 26 of these cases showed no sign of post-traumatic myositis ossificans; only three showed a minimal degree of such abnormal bone formation. Functional results obtained were very satisfactory, as 27 of 28 patients had complete function of their elbows, while one case showed limitation of extension of 5 degrees. None of these patients complained of any distress and all showed normal power of their extremities.

As this result is quite at variance with others reported extensively in the literature and reviewed in this paper, the author comes to the following conclusions: Traumatic myositis ossificans following dislocation of the elbow cannot be attributed to the primary trauma of the dislocation nor to the secondary trauma of the reduction as long as no over-extension was used. It must be attributed to the consequences of the after-care, particularly early physiotherapeutic management, massage, and forced passive motion. If, following reduction, the injured cartilages and the torn joint capsule, ligaments, and muscles are thoroughly immobilized for three weeks (preferably and most safely by a plaster cast), then all injured parts regenerate to such a satisfactory degree that circulatory or nutritional disturbances never occur, such as lead

to permanent limitation of function or to myositis ossificans, traumatic arthritis, and osseous atrophy. Such unpleasant after-effects, however, are caused frequently by additional injurious irritations.

The author gives the following rules for treatment of dislocations of the elbow:

1. Each dislocation of the elbow must be reduced at the earliest possible time through a suitable, carefully guarded procedure—no hyperextension!
2. The dislocated bones have to be immobilized following reduction for a time sufficient to permit of healing of the torn ligaments and other soft tissue tears (average, three weeks).
3. During this time of immobilization of the reduced articulation the other joints of the injured extremity and of the entire body should be moved actively, with avoidance of pain, so as to prevent disturbances in circulation, atrophy of muscles and bones, and stiffening of joints.
4. After removal of the plaster cast neither massage nor passive motion ever is used. Instead, gradually increasing active use is encouraged as long as it does not produce pain. Each injured individual is instructed not to permit anybody else to touch the injured extremity; in particular, to apply massage or passive motion.

The paper is illustrated by a large number of excellent reproductions of roentgenograms.

H. A. JARRE, M.D.

Contribution to the Symptomatology of *Ostitis cendensans ossis ilei*. R. Goedel. Fortschr. a. d. Geb. d. Röntgenstrahlen, September, 1936, **54,** 256–258.

One case of this relatively rare disease was first described by Barsony and Polgar in 1928. This patient was under observation during seven years and while the typical appearance of the condensing osteitis of both iliac bones adjacent to the sacro-iliac synchondroses was observed three weeks after the onset of complaints, the progress of demonstrable changes was found to be extremely slow, so that undoubtedly the disease had already existed for several years before first being observed. In contrast to the frequency noted by Hungarian authors, the affliction undoubtedly is very rare in Vienna. It should not be confused with chronic sacro-iliac arthritis and probably results from a multitude of etiologic factors.

H. A. JARRE, M.D.

Etiology and Pathogenesis of Solitary Bone Cysts. W. Weber. Fortschr. a. d. Geb. d. Röntgenstrahlen, June, 1936, **53,** 861–876.

This paper represents an inaugural dissertation written under the guidance of Prof. Dr. A. v. Albertini, of Zürich, Switzerland. It contains a report of five cases of solitary bone cyst and leads to a review of the present conception of such cavities. Excluded from consideration are parasitic cysts, generalized skeletal disease like osteodystrophia fibrosa generalisata, osteomalacia, rickets, scurvy, senile osteoporosis, deforming arthritis, Paget's disease, true bone tumor with central destruction, callus-cyst, cavity formation in bones which can be related to displaced epithelial anlage, bone-abscess and cavity formation in cases of periostitis albuminosa, and finally encapsulated cavities following chronic osteomyelitis.

Four of the cysts reported were found in patients between 11 and 20 years of age; the last represents a typical post-traumatic hematoma-cyst in the corticalis and was found in a man 29 years of age.

In three of the cases reported a cyst was well formed at the time a trauma took place and a pathologic fracture occurred. In none of the five cases was there any residual evidence of a previous, possibly resorbed giant-cell tumor. The view that bone cysts should be correlated to preceding trauma is declined. The conception of von Mikulicz is supported, assuming that solitary bone cysts represent congenital developmental disturbances or post-natal disturbances in growing bones. The assumption of Geschickter and Copeland is cited in support of von Mikulicz's theory. (It appears to the reviewer, however, that these two American authors would not be in conformity with the author in regard to the etiology of solitary bone cysts.)

H. A. JARRE, M.D.

Bone Changes in Chronic Fluorine Intoxication: A Roentgenographic Study. Paul A. Bishop. Am. Jour. Roentgenol. and Rad. Ther., May, 1936, **35,** 577–585.

Due to disturbance of natural distribution of the more concentrated forms of fluorine in minerals and agricultural activities, the hazard of chronic intoxication from the ingestion of fluorine salts is increasing. Inhalation of these salts or fluorine gas appears to produce no ill effects.

The most evident general symptoms of chronic fluorine intoxication are loss of weight, impairment of growth in young individuals, loss of appetite, and cachexia. Mottled discoloration and pitting of tooth enamel occur during the period when the enamel is being laid down on the permanent teeth in regions where fluorine is present in the water. No effect is produced on teeth that are already permanent. The damage done outlasts the exposure, and recovery is never complete.

Most of the fluorine salts are soluble and eliminated but some combine with calcium, forming an insoluble salt which is deposited in the bones permanently. Low calcium intake hastens the onset and development of symptoms, while a liberal calcium intake tends to offset these effects.

Roentgenologic changes in the case reported by the author and the group of Flemming-Møller and Gudjonsson are as follows: increase in bone density without alteration of normal bone structure, lack of normal sharpness of the bone outlines, and extension of calcification into ligamentous attachments. When the involvement is great the density is so homogeneously marked as to obliterate the bone detail.

The earliest changes appear in the vertebræ and pelvis and as the disease progresses it extends to the periphery, until even the bones of the hands, feet, and skull are involved. Normal osseous architecture is preserved, and there are no destructive changes in the trabeculæ. The indistinct margins of the bones are the result of extension of calcification into the soft tissue at the attachment of ligaments and muscles, and thus in the spine, spurring and even complete bridging between vertebræ may occur and produce stiffness. The intervertebral and articular cartilages are not involved.

This condition is benign and must be differentiated from metastatic carcinoma.

S. M. ATKINS, M.D.

BONE DISEASES (THERAPY)

The Treatment of Primary Malignant Changes of the Bone by Radical Resection with Bone Graft Replacement. Fred. H. Albee. Jour. Am. Med. Assn., Nov. 21, 1936, **107,** 1693–1698.

The author presents 13 cases in which radical resection of a tumor in a bone was carried out, this being followed by a plastic bone graft replacement.

In a number of selected cases at least, it was possible to free the patient from a malignant condition of the bone and to preserve a useful extremity.

After everything has been said, the most important lesson to be derived from these 13 cases over a period of 17 years is that there has been no local recurrence of the tumor. From this point of view the procedure has proved as safe as amputation.

CHARLES G. SUTHERLAND, M.B. (Tor.).

BREAST CANCER

The Fate of the Patients with Carcinoma of the Breast Treated at the Roentgen Institute in Zurich during 1920–1932. E. Ganz. Strahlentherapie, 1936, **57,** 413.

During the period of 1920–1932, a total of 344 patients with carcinoma of the breast were treated at the author's clinic; 342 were females and two were males. One hundred eighteen cases were operated on and had post-operative irradiation. The three-year survival figures were 56 ± 4.5 per cent; the five-year figures, 40 ± 5.4 per cent; the 10-year figures, 18 ± 6.8 per cent. In the group with pre-operative irradiation plus post-operative irradiation, the available number of patients is still too small from which to draw any definite conclusions. Those treated palliatively because of the advanced state of the disease received some benefit. Out of a total of 65 cases, 4 ± 2.4 per cent were alive after three years, 4 ± 2.7 per cent lived after five years, and no patient reached the 10-year period. One hundred thirty-three patients with metastases were irradiated; 21 ± 3.5 per cent lived three years, 10 ± 2.7 per cent lived five years, and 2 ± 1.4 per cent lived 10 years. It was rather striking to note at what late stage of the disease the majority of patients presented themselves for treatment. Technic of treatment: For post-operative irradiation, one supraclavicular and one anterior breast-axillary area receive 360 r. The dose is repeated after eight days, after three weeks, and then at intervals of three weeks, one, two, and three months (150 kv., 3 ma., 3 mm. Al, 40 cm. F.S.D. for breast and axilla; 170 kv., 3 ma., 0.5 mm. Cu, 30 cm. F.S.D. for the supraclavicular area). For pre- and post-operative irradiation, daily doses of 200 r up to total doses of 4,000 r are given through two tangential areas before operation (180 kv., 3 ma., Thoraeus filter, 40 cm. F.S.D.). Seven weeks after this treatment operation is performed. Post-operative irradiation is given according to the technic outlined above. For the palliative group, daily doses of from 180 to 240 r up to total doses of 7,000 r are applied over two tangential areas. The technic is the same as for pre-operative irradiation. The metastatic lesions receive 300 r five or six times per field (180 kv., 3 ma., 1 mm. Cu, 30–40 cm. F.S.D.). Involved glands are treated with the same technic by giving 200 r daily up to 4,000 r total dose. Based on a total number of 3,599 cases operated on only, the five-year cure amounted to 31.2 ± 0.7 per cent. The respective figure for 2,044 patients treated by operation plus irradiation is 40.9 ± 1.09 per cent. Mathematical analysis shows that this corresponds to a minimum of 6 per cent (theoretical calculation) or 1.6 per cent (empirical calculation) in favor of the combined method.

ERNST A. POHLE, M.D., Ph.D.

Roentgen Therapy of Primary Carcinoma of the Breast and the Doses Used Expressed in International Roentgens. J. H. D. Webster. Strahlentherapie, 1936, **57,** 175.

The author outlines the dosage for several technics which may be used in roentgen therapy of carcinoma of the breast. For details of the r values, the reader is referred to the original article.

ERNST A. POHLE, M.D., Ph.D.

Lung Changes Subsequent to Irradiation in Cancer of the Breast. Elwood Emerson Downs. Am. Jour. Roentgenol. and Rad. Ther., July, 1936, **36,** 61–64.

From a study based on 70 necropsies, among which were 53 cases that had received irradiation to the chest, with intensities varying from the low to the high and 1 mm. Al filter to 2 mm. of copper, and to as much as 10,000 r, it was concluded that fibrotic changes in normal lungs subsequent to irradiation are infrequent. Either of two distinct reactions may occur:

(1) A pleuropulmonitis, an edematous reaction which is transient, usually disappearing within a year, if the lungs are otherwise normal. In this reaction a foggy density is seen, usually extending from the hilus to the periphery. At times it is patchy and pleural

involvement may be present. This may occur in from two to eight weeks after completion of a series of intensive treatments, but more commonly following a second or third series of less intensity.

(2) A fibrosis, which is permanent but rarely occurs unless the lungs are previously made vulnerable by metastasis, chronic disease, or infection.

S. M. ATKINS, M.D.

Sterilization in Carcinoma of the Breast. E. Gerard Smith. Am. Jour. Roentgenol. and Rad. Ther., July, 1936, **36,** 65–72.

Based on 12 patients of their own, whom they report in detail, and the review of the literature, the author believes that all women with carcinoma of the breast who have not reached the menopause should receive a sterilizing dose to the ovaries.

In certain cases marked improvement follows, as evidenced by disappearance of metastatic nodules in the skin, shrinkage of metastatic glands, improvement of blood picture, sclerosing of lytic changes in bone, alleviation of pain, and improvement of general health.

Life does not appear to be prolonged by this sterilization, though the course is less painful, nor can conclusions be drawn as to the effect of the time interval of appearance of metastases.

The roentgen prescription was as follows: 200 kv., 4 to 20 ma., 0.5 mm. Cu plus 4 mm. celluloid filter, 50 cm. distance, anterior and posterior pelvis through 20 × 20 or 15 × 15 cm. fields given in daily doses of 200 to 300 r till 600 to 1,200 r were administered both anteriorly and posteriorly.

S. M. ATKINS, M.D.

CALCIFICATION

Generalized Tuberculous Lymphadenopathy. G. Battigelli. Fortschr. a. d. Geb. d. Röntgenstrahlen, July, 1935, **52,** 53–64.

A report of several cases of widespread lymphadenopathy, with clinical and roentgenologic observations, the disease terminating in healing, with unusually extensive calcifications. There is a review of the literature, especially the Italian.

H. A. JARRE, M.D.

Ossification of the Stylohyoid Ligament. A. Beutel. Röntgenpraxis, October, 1935, **7,** 665–670.

Two cases of ossification of the stylohyoid ligament are reported and the clinical importance of such anomalies is pointed out. In one case the left stylohyoid ligament consisted of a chain of bony tissue extending from the base of the skull to the cornu of the hyoid bone; on the right side there was only an abnormally long styloid process.

In the second case a very long left styloid process was found, together with a long cornu of the hyoid bone, formed by ossification of the stylohyoid ligament and calcification in the hyothyreoid ligament.

HANS W. HEFKE, M.D.

CANCER (DIAGNOSIS)

The Transformation of Gastric Ulcer into Gastric Carcinoma. J. William Hinton and Max Trubek. Surg., Gynec. and Obst., January, 1937, **64,** 16–21.

The authors reviewed 118 cases of gastric carcinoma with the idea of studying the question of the transformation of gastric ulcer into gastric carcinoma. McCarty considered 68 per cent of gastric ulcers precancerous lesions. Wilensky and Thalhimer reported an incidence of from 1 to 2 per cent of gastric carcinoma in patients with gastric ulcers.

The average duration of symptoms in the authors' group of gastric carcinoma was 45.3 weeks. On the other hand, in a group of 104 gastric ulcers also reviewed by the authors, the ulcer symptomatology averaged 4.5 years.

Of the 118 cases reviewed, 38 patients were submitted to operation and in 11 of these a resection was done. Twenty-three patients of the 38 died following operation. Of the group of 80, 32 patients who were not operated on died in the medical wards. In 12 of these cases an autopsy was performed.

In the group of 104 cases of gastric ulcers, there were nine cases in which there was an element of doubt as to a gastric malignancy. In six of these patients, inflammatory lesions were found at operation. One patient refused operation, and in the remaining two cases evidence of carcinoma was found. In each of these two cases the clinical diagnosis was carcinoma, but the roentgen-ray findings were considered those of gastric ulcer.

The authors conclude that in their two groups of ulcer and of carcinoma, they have failed to find evidence of the transformation of a gastric ulcer to gastric carcinoma in a single case. However, they believe it is possible that in some cases it is difficult to differentiate between a benign ulcer and an early ulcerating carcinoma. These questionable cases, which make up only from 6 to 7 per cent of the total, should be resected.

J. N. ANÉ, M.D.

CANCER (THERAPY)

The Principles Governing the Radiation Therapy of Cancer. George T. Pack. Am. Jour. Roentgenol. and Rad. Ther., August, 1936, **36,** 233–244.

In each case of malignancy in which radiation is to be employed, an attempt should be made to determine in the beginning whether to try for cure or only palliation. Tumors of embryonal origin are for the most part radiosensitive, but there are exceptions in adult testicular teratoma and some mixed cell tumors. Again cellular, rapidly growing undifferentiated tumors with

numerous mitoses should be responsive, yet neurosarcoma and melanoma are notoriously resistant.

In principle, all radiation is either external (either x-rays or radium), intracavitary, or interstitial (radium only).

The tissue dose within the tumor, usually expressed in threshold erythemas, is the smallest amount of radiation absorbed by any part of the tumor. The cancericidal dose for certain malignant tumors has been fairly well determined; for example, intra-oval squamous-cell carcinomas require 6 to 8 T.E.D., while transitional cell carcinomas and lympho-epitheliomas require only 2 to 4 T.E.D. Some radiosensitive mammary carcinomas will also disappear under relatively small doses but resistant breast cancers require as much as 10 T.E.D.

It has recently been estimated that x-rays resulting when a potential of 1,500,000 volts is available will approach the quality (or shortness of wave length) of gamma rays of radium. However, even were such x-rays widely available, they would not render obsolete the use of radium, the latter being essential for intracavitary and interstitial radiation.

The effective wave length of x-rays depends upon the factors of potential and the atomic weight of the target; however, only the former is varied in practical usage.

There is still some difference of opinion as to the significance of wave length in influencing tissue reactions. The only difference in electrons from very high voltage and low voltage x-rays is one of speed, but this difference in speed has an influence on the number of ions produced in the tissues per unit length of the path, and the difference in concentration of the ions may alter the rate of recombination of ions and thereby influence the chemical changes, on which radiation effects presumably depend finally. The sequence of events in the tumor cell appears to be: (*a*) ionization; (*b*) chemical changes, and (*c*) biologic effects.

There is good evidence, both experimental and clinical, to show that due to greater recuperation powers of normal tissues, low intensity and prolonged time of irradiation (within certain limits) will have greater differential destructive effect on tumor cells than on normal cells. This principle has been carried still further by a few workers who are using weak intensity roentgen rays from 8 to 12 hours per day over a period of weeks (Heublein method).

J. E. Habbe, M.D.

Experiments Regarding the Treatment of Skin Cancer with Very Soft Roentgen Rays. E. Ebbehoj. Strahlentherapie, 1936, **57,** 661.

The author treated superficial carcinoma of the skin with roentgen rays produced at 12 and 25 kv. Doses of 20,000 r applied in one sitting destroyed carcinoma of 1 mm. depth; it healed with a barely visible scar. For 25 kv. the dose amounted to 5,600 r and was applied to cancers of a depth of from 2 to 3 mm. Illustrations of patients before and after treatment are appended.

Ernst A. Pohle, M.D., Ph.D.

The Radiological Treatment of Cancer, 1929–1935: IV.—Carcinoma of the Lips. G. E. Richards. Canadian Med. Assn. Jour., November, 1936, **35,** 490–502.

The author studied the treatment of oral malignancy by roentgenology and surgery. This paper considers malignancy of the lip, consisting of 334 cases of carcinoma and one case of sarcoma. Only previously untreated cases were used. Of the total, ten were in females and six were lesions of the upper lip. The ages ranged from 20 to 95 years. The lesions were classified according to the size of the primary lip lesion and the extent of cervical lymphatic involvement.

The treatment of the primary localized lesions exclusively by radiological methods, including the entire range of such methods, resulted in the disappearance of the lesions without recurrence in 96.5 per cent of the cases. The results became increasingly less successful as the size of the lesion and glandular involvement increased. The cosmetic results following radiological methods were excellent.

The surgical aspect of the problem is to be reported in the future.

Richards could find no convincing evidence that "external irradiation of the neck as commonly practised for prophylactic purposes can either prevent the development of glandular secondaries or control them, once established."

G. E. Burch, M.D.

The Treatment of Cancer of the Cervix Uteri at the Rhode Island Hospital. Herman C. Pitts and George B. Waterman. Surg., Gynec. and Obst., January, 1936, **64,** 30–38.

The authors described their technic of radium therapy of cervical carcinoma and report a series of 293 cases observed during the period from 1921 to 1931.

In the period from 1921 through 1925 the authors employed a total dose of from 3,000 to 4,000 milligram-hours in two or three treatments, two or three weeks apart. Two 50-milligram tubes filtered by silver and brass in tandem in a rubber tube was used in the cervicouterine canal. One 50-milligram and two 25-milligram tubes and 10 steel needles of 5 milligrams each were either made into a pack and placed against the cervix or in many cases the radium needles were employed interstitially.

In 1926 the plan of treatment was modified and four 3-milligram, 0.5 mm. platinum needles of 45 mm. active length, were placed into the tissues at the sides of the uterus, two on each side. From twelve to sixteen 2-milligram, 0.5 mm. platinum needles of 30 mm. active length, were placed in the tissues at from 1 to 2 cm. intervals in front and back of the cervix. A 20-milligram platinum capsule or the tandem of the two 50-milligram tubes are used in the cervical canal. From 1926 through 1928, the radium was left in place from 72 to 96 hours. In 1929 this time was increased to from 144 to 168 hours.

Of the 293 cases of carcinoma of the cervix examined, 17 were too advanced to treat or refused treatment. The absolute survival rate under the older method of treatment was 20 per cent and under the newer method, 31.7 per cent. The absolute survival rate for the period from 1921 through 1930 was 26.9 per cent. The uncorrected immediate mortality for the entire group was 2.9 per cent. The incidence of fistula under the older method was 9.1 per cent and under the newer method, 6.3 per cent.

J. N. Ané, M.D.

Results of Radiation Therapy of Carcinoma of the Bronchus. H. Engels. Strahlentherapie, 1936, **57,** 445.

During 1926–1933, 92 patients with carcinoma of the bronchus were treated in the University Institute for Radiation Therapy in Frankfort-on-Main. The entire treatment was extended over a period of from four to five weeks. From four to six areas were applied, with total doses of from 6,000 to 12,000 r. Of the patients, 7.6 per cent remained free from recurrences for a period longer than three years. While this number is still small, it demonstrates beyond doubt that carcinoma of the bronchus can be successfully treated by irradiation. A number of illustrative case reports are appended and roentgenograms, made before and after treatment shown.

Ernst A. Pohle, M.D., Ph.D.

The Treatment of Rectal Carcinoma by Surgical Freeing and Exposure to "Close" Roentgen Therapy. H. Chaoul. München. med. Wchnschr., June 12, 1936, **83,** 972–974.

Theoretic considerations are elaborated upon, proving the distinct advantages of this new method. In brief, the technic consists in a preliminary two-stage operation, of colostomy and freeing of involved bowel, by resection of the coccyx and a portion of the sacrum. The colon is incised the length of the bowel through the infiltrated area, permitting direct application of the roentgen tube under visual control. A biopsy is always obtained at this time. Five to ten days subsequently, roentgen therapy is instituted, which consists in irradiating through numerous fields, no larger than 25 sq. cm. each and irradiation of the entire neoplasm even though there be overlapping of fields. This is of no serious importance, mainly because physical experimentation shows a marked falling off of the amount of irradiation at the periphery of the fields, which is explained on the basis of obliquity of rays at the periphery passing through a relatively thicker filter.

In Chaoul's experience rectal carcinoma is but slightly radiosensitive, and a total dosage of from 10,000 to 15,000 r per field is necessary. The surgical freeing of the neoplastic site aids in irradiating the site of lymphatic drainage, which is situated chiefly behind the rectum. Following this intensive irradiation, necrotic areas intermingled with purplish granulations appear, which are used as criteria for cessation of treatment. Unfortunately, many times these areas are difficult to differentiate from malignant tissue. If after from two to three months the carcinomatous involvement is completely eradicated, or even if necrotic areas are well circumscribed, the natural bowel passageway is reconstructed after excision of the involved bowel segment. In nine cases of far advanced, extensive inoperable carcinoma of the rectum, six showed complete disappearance of the tumor. In a single case recurrent areas necessitated further irradiation. It is notable that two cases were of two years' duration clinically, and after efficacious treatment, the patients gained weight and were able to return to their former occupations. In the failures, one case was very far advanced and incompletely mobilized beside; the other case presented resistant recurrences.

In reviewing the German literature, the author estimated that an average of 13 per cent had a five-year survival period, obtained by surgical measures alone. He makes a strong plea for continued trial of this combined surgical-radiologic method, and he feels confident that far better results will thereby be attained.

William R. Stecher, M.D.

The Influence of Electromagnetic Waves on the Freund-Kaminer Cancer Reaction. G. Fuchs. Strahlentherapie, 1936, **57,** 636.

Freund and Kaminer developed a serum reaction called "cytolytic" and protective reaction for the detection of carcinoma. The author studied the effect of roentgen irradiation on the course of the reaction. He found that the serum of a cancer patient would act more like normal serum after exposure to roentgen rays. Following the treatment of cancer serum with short and ultra-short electric waves, it reacted like a normal serum. Long electric waves did not seem to have any effect.

Ernst A. Pohle, M.D., Ph.D.

Roentgen Therapy of Carcinoma and Periodicity of the Epithelial Changes. H. Coutard. Strahlentherapie, 1936, **56,** 577.

The English reader will find the essentials of this article published in the Proceedings of the Institute of Medicine of Chicago, Oct. 15, 1935, Vol. 10, No. 16.

Ernst A. Pohle, M.D., Ph.D.

Roentgen Therapy of Malignant Papilloma and Carcinoma of the Bladder. C. Gil y Gil. Strahlentherapie, 1936, **57,** 32.

After a brief review of some recent publications regarding end-results in the treatment of carcinoma of the bladder, the author analyzes 28 cases which came under his own observation. He used the fractional dose method as practised by Holfelder: 180 kv.; H.V.L. in Cu, 0.95 mm.; 26 r/min. at 30 cm. F.S.D.; 4–5 fields; surface dose per area 1,500 r; total dose in the depth, 2,800 to 3,300 r. The duration of treatment varied from 12 to 21 days. Of the 28 treated cases, 39 per cent were still alive after three years. They were distributed as follows: five out of five malignant papil-

lomas; five out of nine superficial carcinomas, and one out of 14 advanced carcinomas.

The author concludes that electrocoagulated and recurrent papilloma of the bladder can be cured by roentgen therapy. Prophylactic irradiation following electrocoagulation is valuable. The superficial neoplasms are also susceptible to roentgen therapy, while the more advanced type is quite radioresistant.

ERNST A. POHLE, M.D., Ph.D.

THE CECUM

Inversion of the Cecum: Its Relationship to Appendicitis. Ferdinando Talia and Demetrio Constantino. Archivio di Radiologia, March–April, 1936, **14,** 91–107.

Talia and Constantino report the results of a study of 992 patients who had a lesion in the ileo-cecal region and found that in 1.1 per cent there was external rotation of the cecum and in 0.3 per cent internal.

E. T. LEDDY, M.D.

THE COLON

Secondary Resections in Recurring Carcinoma of the Colon. J. W. Thompson. Jour. Am. Med. Assn., Nov. 21, 1936, **107,** 1688–1692.

Carcinoma of the colon is a very common lesion, which occurs at all ages. In approximately 50 per cent of all cases encountered the disease has advanced beyond hope of surgical relief. There is an operative mortality varying from 5 to 35 per cent. Frequently the recovery of the patient is stormy, and in lesions of the rectum and lower part of the colon there is all too often the mutilation and social isolation associated with permanent colostomy. In growths more proximally situated, the problem of colostomy is avoided but the frequency of recurrence is greater. Metastasis to the liver and to regional lymphatic channels is always a specter which haunts the life of the individual fortunate enough to survive operation. The outlook for a patient proved to have even an operable carcinoma of the colon is to say the most, not greatly encouraging.

In lesions of the colon in which there is not definite evidence of metastasis in the liver, recurrence in or about the site of previous operative intervention should not deter one from re-exploration with a second attempt at removal of the neoplasm.

A small series of such cases is presented.

Multiple malignant lesions of the colon are probably not so rare as commonly believed. They may occur simultaneously or develop after a period of many years.

CHARLES G. SUTHERLAND, M.B. (Tor.).

Multiple Polyposis of Colon: Familial Factor and Malignant Tendency. Descum C. McKenney. Jour. Am. Med. Assn., Dec. 5, 1936, **107,** 1871–1876.

Erdmann and Morris divide this lesion into two classes: the first, the acquired or adult type, the result of some form of irritation; the second, the adolescent (congenital, disseminated type) characterized by familial tendency and probably, in some cases at least, congenital. The author considers only the adolescent type. Five cases were selected for group study but in only two was it possible to get in contact with relatives in sufficient number to warrant a re[illegible]

Two facts were pretty well established—this disease does have an hereditary tendency, and, if these individuals live a normal span of life, a malignant growth will develop in the majority of them.

CHARLES G. SUTHERLAND, M.B. (Tor.).

Diverticulitis of the Sigmoid Colon. Roscoe R. Graham. Canadian Med. Assn. Jour., January, 1937, **36,** 1–7.

Graham points out that the limitation of x-ray in the diagnosis of diverticulitis of the sigmoid colon is no reflection on the radiologist nor on the method of examination. The clinician and radiologist must accept an equal responsibility in arriving at a diagnosis. X-ray examination in 30 patients studied resulted in 17 (57 per cent) correct diagnoses. Contrast barium enema proved one of the most useful technics in aiding the diagnosis. The variation of the x-ray defects in cases of diverticulitis and the mimicry in cases of malignancy render impossible in some instances the accurate differentiation of an inflammatory from a neoplastic lesion. Difficulty was also encountered in the ability to assess the progress of the local lesion solely by comparative x-ray studies taken over a period of months. Graham concludes that the responsibility of the diagnosis of the exact nature and progress of this lesion should be shared by the radiologist and the clinician, with the latter holding himself responsible for the final decision.

W. A. SODEMAN, M.D.

CONTRAST MEDIA

Fatal Iododerma Following Injection of Iodized Oil for Pulmonary Diagnosis. D. W. Goldstein. Jour. Am. Med. Assn., May 9, 1936, **106,** 1659, 1660.

Reviewing the literature Goldstein failed to find a report of death following the injection of iodized oil into the lung. He presents the case of a male, aged 47 years, who was admitted to the hospital with an eruption that was more or less limited to the face and upper extremities. Two days before, 20 c.c. of lipiodol (Lafay) had been injected into the lung for diagnostic purposes. The following morning a papulopustular eruption was noted over the forehead and face, which gradually spread to the upper part of the chest and the extensor surface of the arms and hands. The temperature rose to 101.4° F. The patient became nauseated and finally was brought to the hospital in a stupor, the result, no doubt, of a severe toxemia. The urine tests were repeatedly positive for the presence of iodine. The diagnosis was iododerma and acute glomerulone-

phritis. The lesions gradually spread over most of the body. The nephritis became more marked and the patient died twenty-six days after the onset of his illness, of nephritis, plus an overwhelming toxemia.

The author considered it conceivable that in a markedly sensitive or allergic individual a sufficient quantity of iodine could have been absorbed to be responsible for the eruption.

CHARLES G. SUTHERLAND, M.B. (Tor.).

THE CRANIUM

Lesions Involving the Cranium and its Contents. Charles G. Sutherland. Am. Jour. Med. Sci., November, 1936, **192,** 735–744.

The author very briefly reviews the use of roentgenology in the diagnosis of lesions involving the cranium and its contents. The review considers the developments of the past two to three years, using the most significant advancements of the more remote past to link present roentgenologic practices.

G. E. BURCH, M.D.

DERMOID CYST

A Roentgenologic Criterion of Dermoid Cyst. Dallas B. Phemister, William B. Steen, and John C. Volderauer. Am. Jour. Roentgenol. and Rad. Ther., July, 1936, **36,** 14–18.

A new sign in the diagnosis is presented, namely, a fluid level that shifts with the position of the patient. This is due to the fat which is present being liquid at body temperature. Absence of this sign is not dependable negative evidence since presumably some dermoids will not contain a suitable mixture of nonlipoid and lipoid material. A case is presented.

S. M. ATKINS, M.D.

DIABETES

Hypertension and Diabetes: Their Treatment by Radiotherapy. James H. Hutton. Am. Jour. Roentgenol. and Rad. Ther., June, 1936, **35,** 813–817.

During an interval of a little over two years 157 cases of hypertension have been treated with small doses of radiation over the pituitary and adrenal glands. Of these, 97 were improved, 24 unimproved, and 37 either insufficiently treated or not followed. During the same interval, 18 cases of essential hypertension and diabetes were similarly treated, of which seven were improved as to both conditions, four as to hypertension only and three as to diabetes only, and three were insufficiently treated or not followed. Of 45 cases of diabetes without hypertension treated, 20 improved, 12 did not improve, and 13 were insufficiently treated or not followed.

The technic is 120 kv. p., 10 × 10 cm. portals over each side of the head, and 15 × 15 cm. portal for the two adrenals, 50 cm. distance, 76 roentgens. Treatments are given at weekly intervals, or at longer intervals if the blood pressure begins to fall, a series consisting of six treatments each of the above fields.

J. E. HABBE, M.D.

Roentgen Irradiation through the Temples for Diabetes Mellitus. Corrado Montefusco. Archivio di Radiologia, 1935, **11,** 397–403.

The author, in the three cases he studied, was unable to demonstrate a definite change in the elimination of water, the chloride or the carbonate balance after bitemporal irradiation. There was a slight lowering of the glicemic level and a slight elevation of the cloremic level.

E. T. LEDDY, M.D.

DOSAGE

Variations in the Technic and Biologic Effects of Fractionated Doses of X-radiation. H. E. Martin. Strahlentherapie, 1936, **57,** 73.

The author says that "the protracted dose principle therapy has opened up entirely new vistas in the treatment of malignant tumors. The possibilities of this method have not been exhausted by its application to pharyngeal tumors, nor by the use of x-radiation alone. Except in the relatively easy problems of radiation therapy, such as the treatment of small cancers of the skin, it seems probable that the protracted dose principle will prove to be generally preferable to the massive dose method. If in certain anatomic locations, interstitial or intracavitary radium is preferable to x-rays, the protracted dose method may still be advantageous. A partisan attitude toward any one method of therapy, whether it be toward surgery, x-rays, or radium, may, in certain instances, be productive of rapid developments from the purely scientific standpoint, but on the whole, we believe that cancer therapy and the interests of the cancer patient are best served by a fair-minded and intelligent application of variations and combinations of all methods, in most cases."

ERNST A. POHLE, M.D., Ph.D.

The Use of Roentgen Rays of Moderate Wave Length in the Treatment of Certain Diseases. R. Reynolds. Strahlentherapie, 1936, **57,** 132.

The author believes that there is a group of diseases which responds well—if not better—to roentgen rays of moderate penetration. He feels that in view of the present tendency for higher voltages, this fact should be kept in mind. A few examples are quoted in the paper. In chronic mastitis, a potential of 80–100 kv., no filter, half a skin dose given three times at weekly intervals, usually suffices. In chronic myelogenous and lym-

phatic leukemia, irradiation may be started with 80–100 kv., 0.5 mm. Al, one skin dose over two areas over the enlarged spleen. The same dose is given over the long bones. After from five to seven days the treatment may be repeated. In severe cases, one-half of the skin dose is sufficient. If the treatment has to be conducted over a longer period, 120–180 kv. filtered through 3 mm. Al or 0.5 mm. Cu + 3 mm. Al is the preferable technic. Lymphadenoma is treated with 90 to 100 kv., filtered through 0.5 mm. Al, and half a skin dose. In the author's experience the masses disappear often in from four to five days. Chronic tuberculous affections seem to respond well to one-half to three-quarters of a skin dose with potentials of from 120 to 160 kilovolts. This dose can be given once a week or even less frequently: improvement may be expected in the course of two or three months.

ERNST A. POHLE, M.D., Ph.D.

Practical Experiences with the Reliability of Indirect Dosimetry. H. Holthusen. Strahlentherapie, 1936, **57,** 459.

The author describes the method of calibration of the x-ray apparatus for therapy in his institute. He measures the output in r (in air) and calculates the dose on the surface. This "indirect" method has proved reliable over a sufficient number of years to warrant its recommendation. Especially, valve tube equipment has improved the constancy of output to render the method practical. The skin reactions observed after doses determined in this manner proved to be so similar as to offer a biologic test for its accuracy.

ERNST A. POHLE, M.D., Ph.D.

A Method for the Concentration of Roentgen Rays in the Depth. V. Maragliano. Strahlentherapie, 1936, **57,** 299.

In order to improve the depth dose of roentgen rays the author constructed an apparatus which converges the beam of the radiation. The device, called a "concentrator of rays," consists of a thick block of paraffin resting on a lead filter which has an opening. A lead cylinder is attached which contains numerous small canals arranged in spiral shape. The entire cylinder is rotated by a motor. Due to this arrangement the emerging radiation is said to be homogeneous. A few sketches are appended, illustrating the apparatus and its working mechanism.

ERNST A. POHLE, M.D., Ph.D.

Dosage of Gamma Rays by Ionization Measurements. G. W. C. Kaye and W. Binks. Strahlentherapie, 1936, **56,** 608.

At the last International Congress in 1934 the authors expressed the opinion that the "roentgen" can be used for determining the dose in radium therapy. They studied the problem further with 100 and 180 mg. of radium, respectively, filtered through 0.5 mm. Pt. When using a well defined beam of radiation, a large open air ionization chamber as well as a chamber with walls made of air-equivalent material can be used. If scattering is avoided, the air wall chambers are suitable for measurements in the beam without diaphragms. The measurements showed that the unit proposed by Sievert (1 mgh. at 1 cm. distance) corresponds to about 7.7 r.

ERNST A. POHLE, M.D., Ph.D.

Dosimetry in Radiation Therapy. I.—Gamma-ray Measurements in Roentgens. Otto Glasser and Leopold Rovner. Am. Jour. Roentgenol. and Rad. Ther., July, 1936, **36,** 94–104.

Experimental studies of the standard air chamber during the past few years have shown it to be incapable, in its present form, of measuring the true value of free air ionization produced by radiations of very short wave lengths.

These limitations of operating range do not seem to affect ionization measurements made with the small enclosed type of chamber when measurements are made in a large volume of irradiated air.

A series of studies of the adequate nature of air wall materials for enclosed chambers has been put forth by many authors, and seems to find a useful unification of result in the measured values of the radium ionization constant: r/mgeh-cm. (roentgens per milligram-element-hour at 1 cm. distance). The constant r/mgeh-cm. can thus properly serve as a standard upon which to base the ionization measurements of ultra-short wave radiations.

The authors have conducted further measurements on the value of r/mgeh-cm. and have obtained results in general agreement with their earliest measurements, and with the work of other authors. Their value of the air ionization constant for gamma radiations of Ra B and Ra C, filtered by 0.5 mm. Pt, is 8.8 r/mgeh-cm.

S. M. ATKINS, M.D.

ENCEPHALOGRAPHY

Cerebral Roentgenoscopy as an Aid in Pneumoventriculography and Encephalography. A. J. Bendick and Ben H. Balser. Am. Jour. Roentgenol. and Rad. Ther., June, 1936, **35,** 790–794.

When injected with air the entire ventricular septum is readily visualized on the fluoroscopic screen. The authors make practical application of this fact in the making of ventriculograms and encephalograms by placing the patient, into whose cerebrospinal system air has previously been injected, into the optimum Trendelenburg and semi-erect angles under roentgenoscopic guidance for filming the ventricles.

J. E. HABBE, M.D.